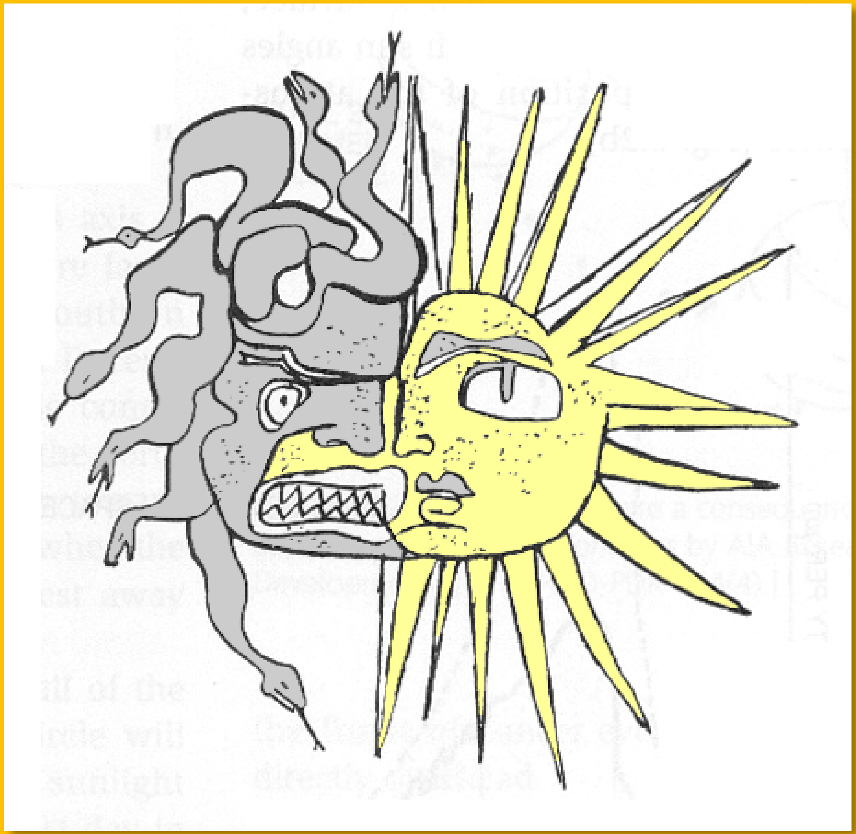
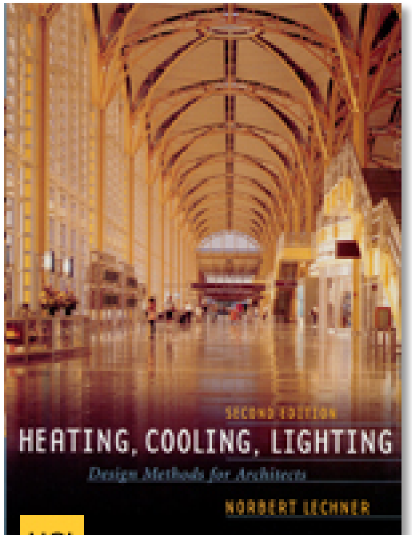
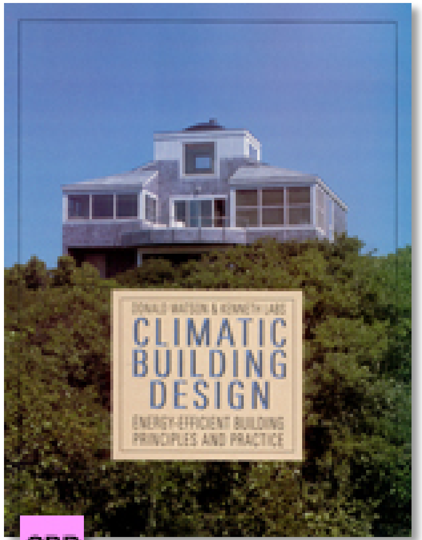
Arch 125: Intro to Environmental Design

SOLAR GEOMETRY + ORIENTATION



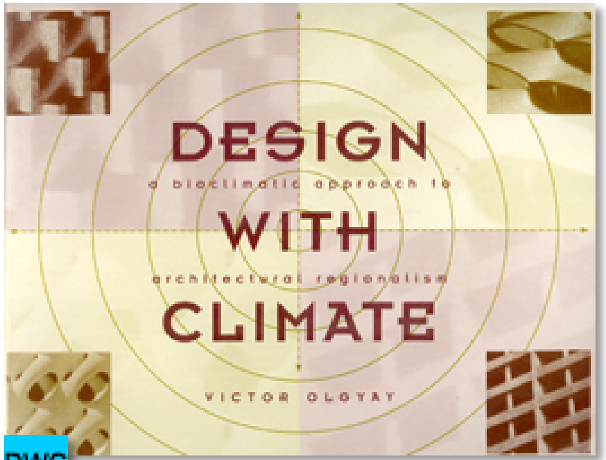


HCL



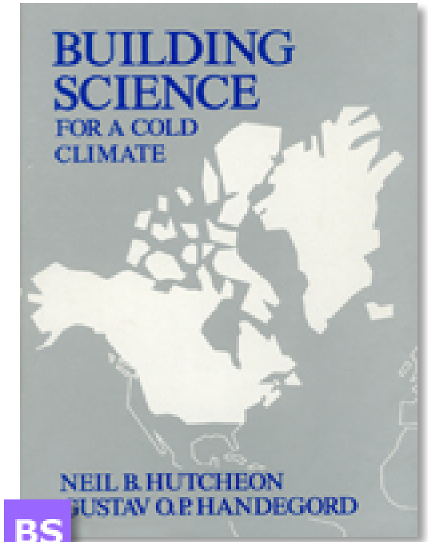
CBD

SWL



DWC

ECS



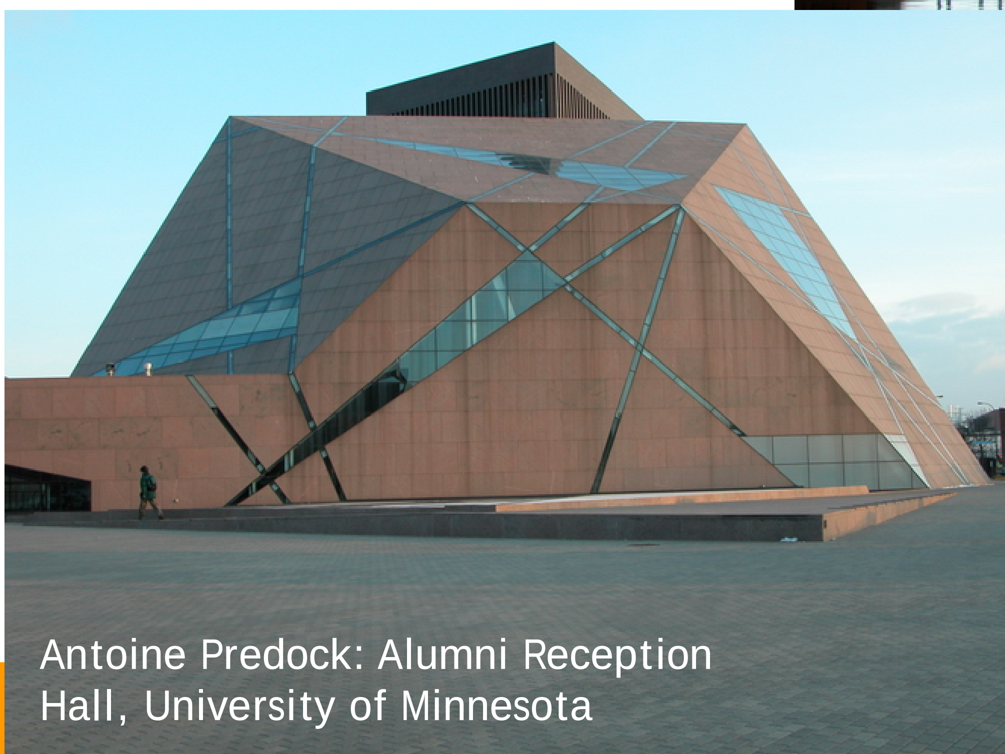
BS

Texts used in the preparation of this presentation.

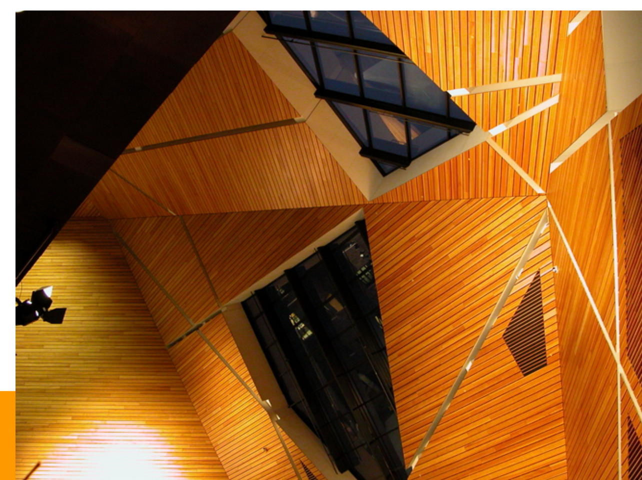
There are large numbers of buildings that treat windows as patterning devices, and that do not take advantage of the sun in *obvious* ways.

In fact, the windows at the right ARE Morse Code.

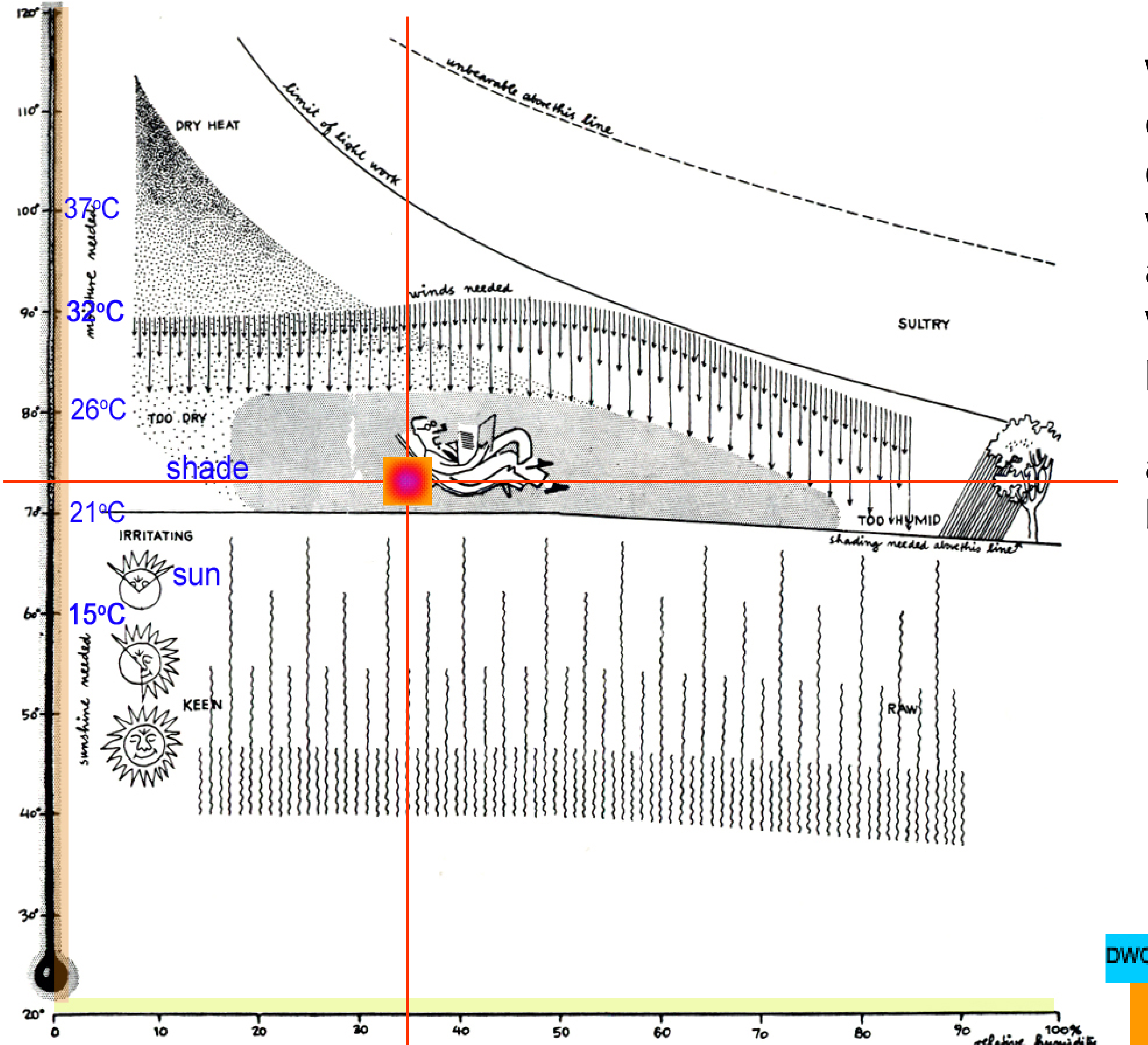
…time of day affects windows…



Antoine Predock: Alumni Reception Hall, University of Minnesota



In studying Solar Geometry we are going to figure out how to use the sun's natural path in summer vs. winter to provide FREE heat in the Winter, and to reduce required COOLING in the summer + USE IT TO ANIMATE OUR SPACES.



46. Schematic bioclimatic index.

We use this chart to determine when we DO and DO NOT want sun penetration in and around our buildings.

Why Solar Geometry?

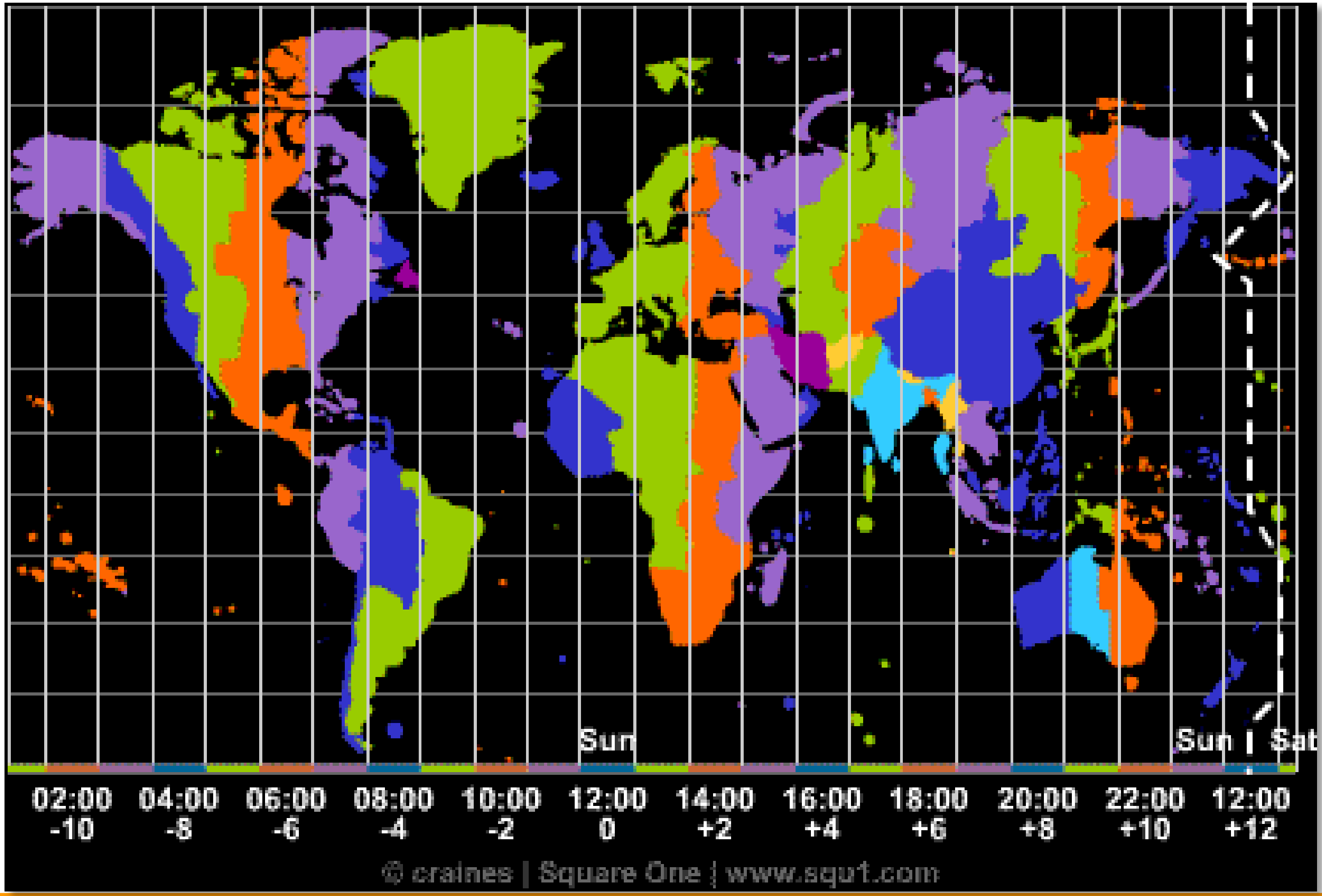
Understanding solar geometry is essential in order to:

- do passive building design (for heating and cooling)
- orient buildings properly
- understand seasonal changes in the building and its surroundings
- design shading devices
- use the sun to animate our architecture

Solar geometry works for us because the sun is naturally HIGH in the summer, making it easy to block the sun with shading devices on south façades.

And it is naturally LOW in Winter, allowing the sun to penetrate below our shading devices and enter the building - with FREE heat.

The time zone is important as it affects "solar noon". All charts are based on solar noon not the "hour noon". Easiest way to find solar noon for your location is to note the sunrise and sunset times (in the paper/net) and solar noon is halfway in between.



Detailed weather data is available online at:
http://www.weatheroffice.ec.gc.ca/city/pages/on-150_metric_e.html

For example: for Collingwood, Ontario for Sunday, Jan 22, 2006

Sunrise 7:50, Sunset 17:15, Moonrise 0:44, Moonset 11:12

So… solar noon is halfway between 7:50 and 17:15, so

4:10 + 5:15 = 9:25 / 2 = 4:42.5 (4 hours 42.5 minutes),
so at 42.5 minutes after 12 noon.

Toronto was 7:44 and 17:14

The rotation of the earth about the sun affects the amount of solar radiation we receive at varying times of the year.

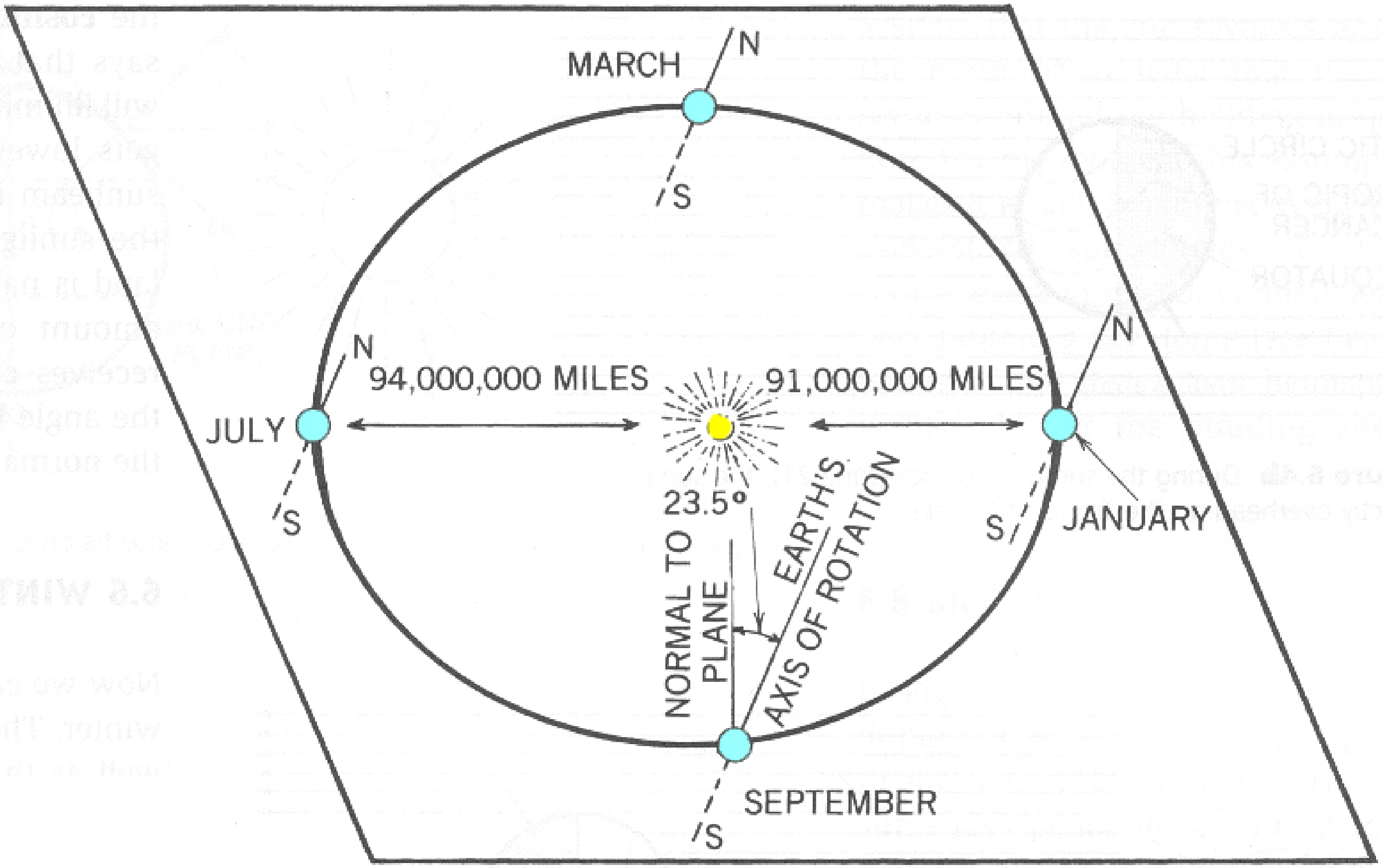
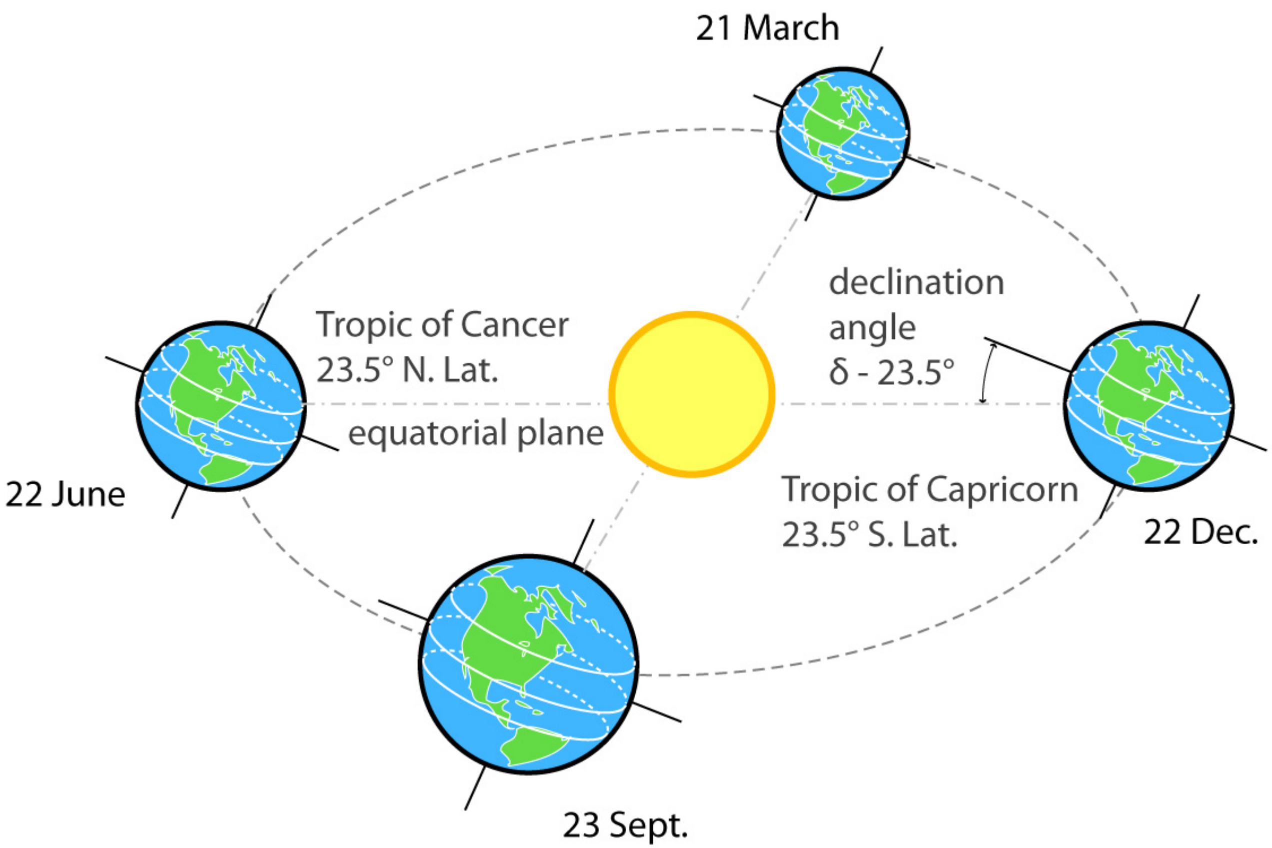


Figure 6.3 The earth's axis of rotation is tilted to the plane of the elliptical orbit.

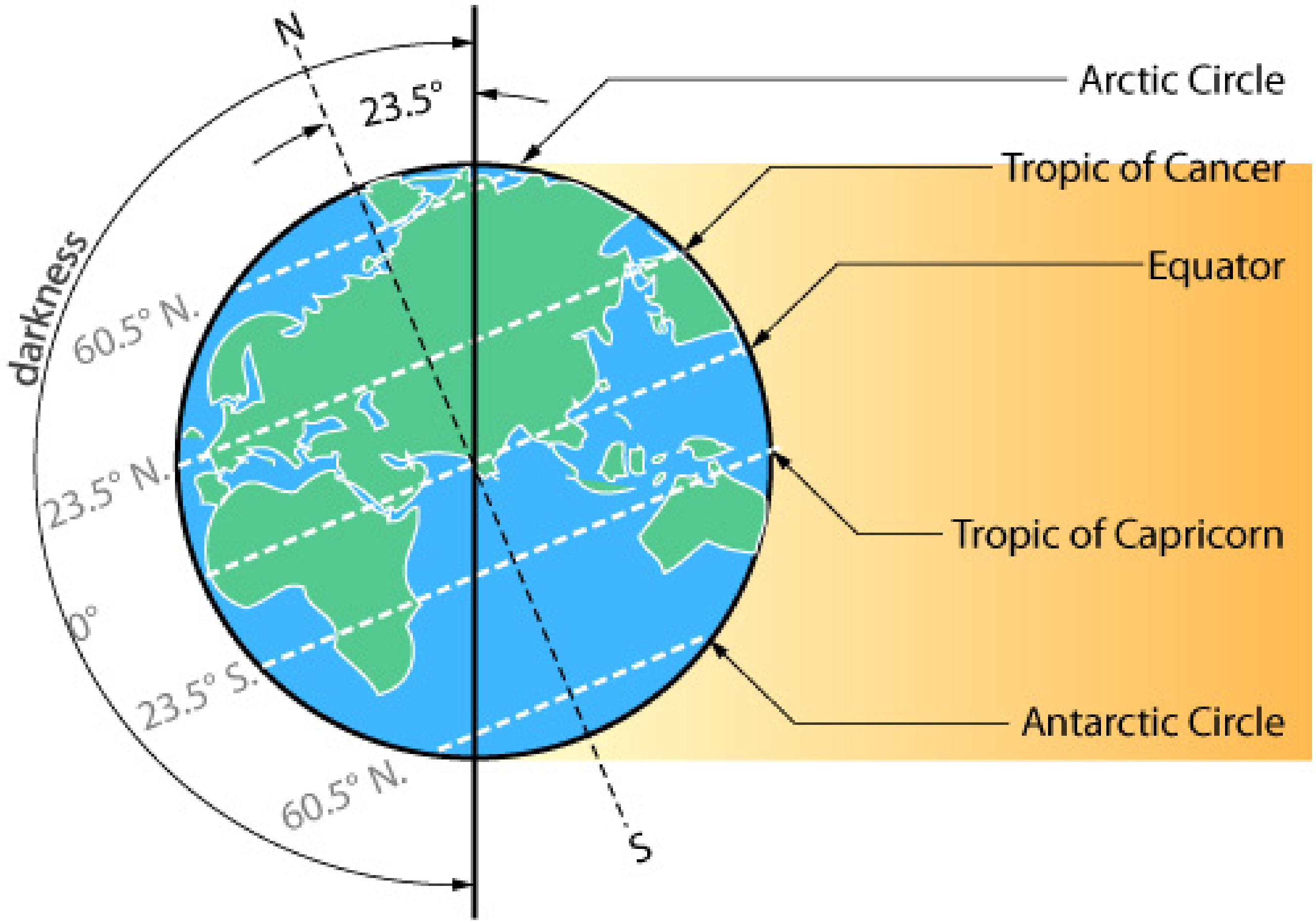
HCL

Solar Position



Earth's motion around the sun.

Solar Position



Earth relative to sun at winter solstice.

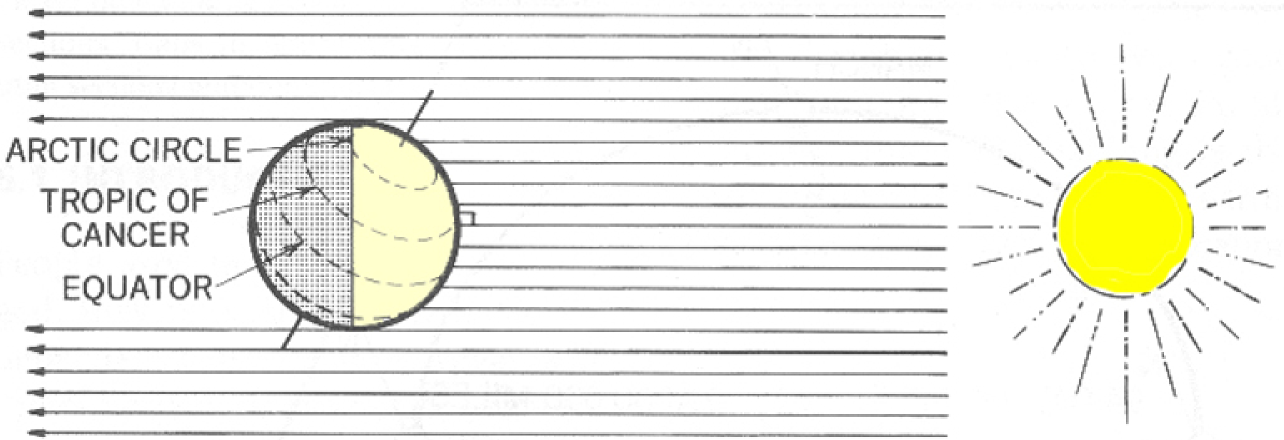


Figure 6.4b During the summer solstice (June 21), the sun is directly overhead on the Tropic of Cancer.

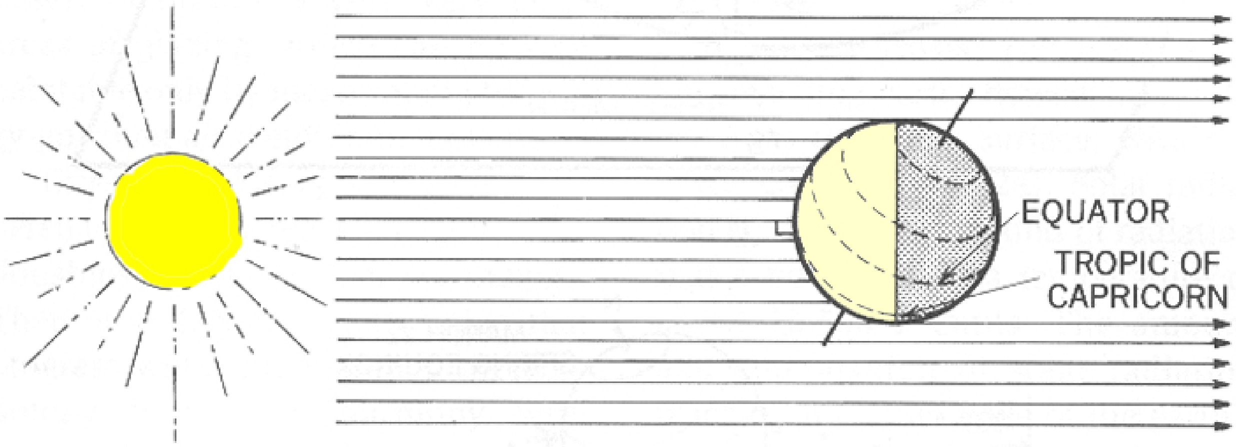


Figure 6.4c During the winter solstice (December 21), the sun is directly overhead on the Tropic of Capricorn.

HCL

Solar Position

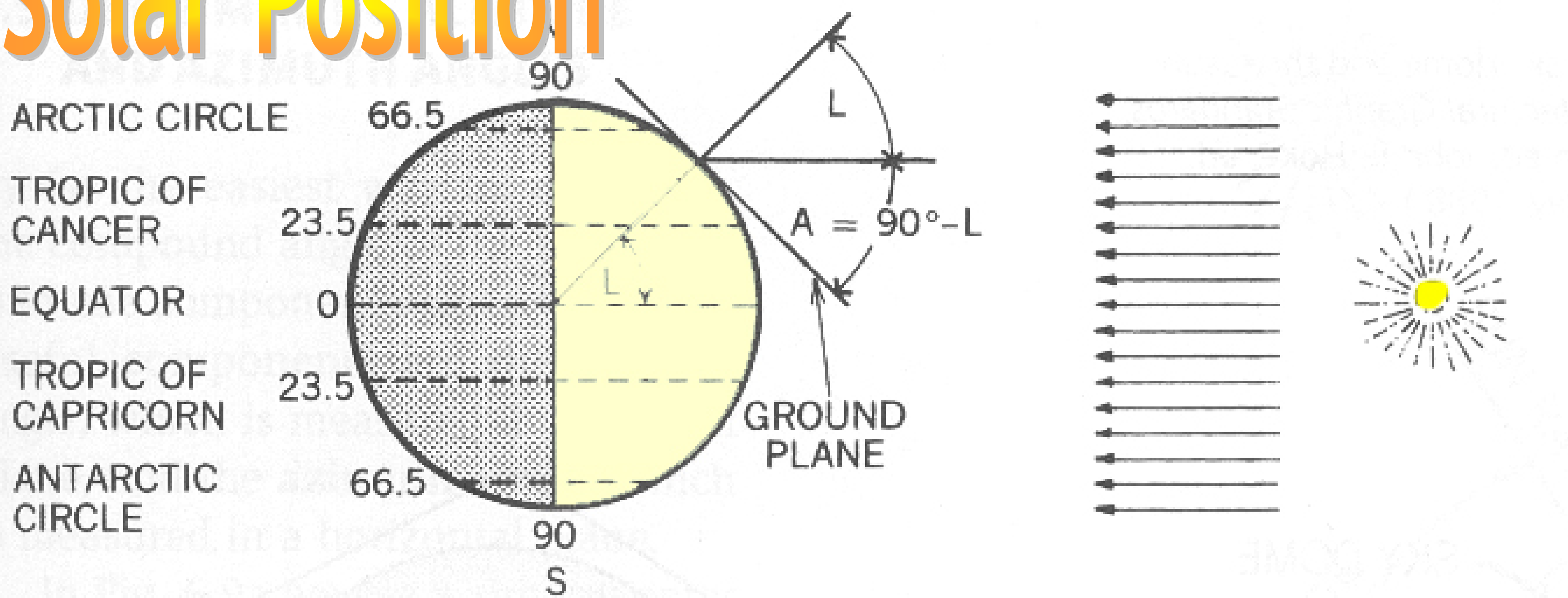
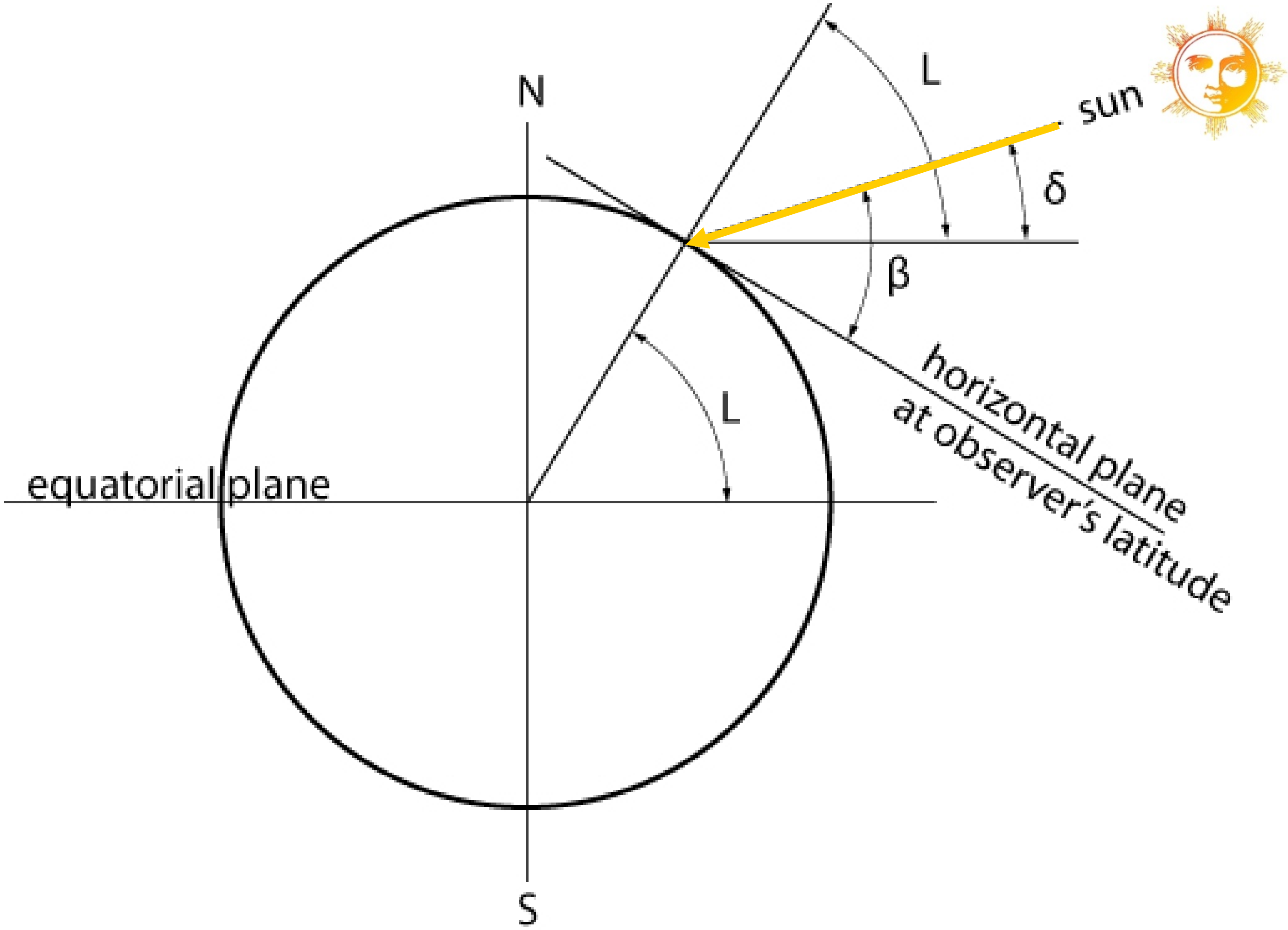


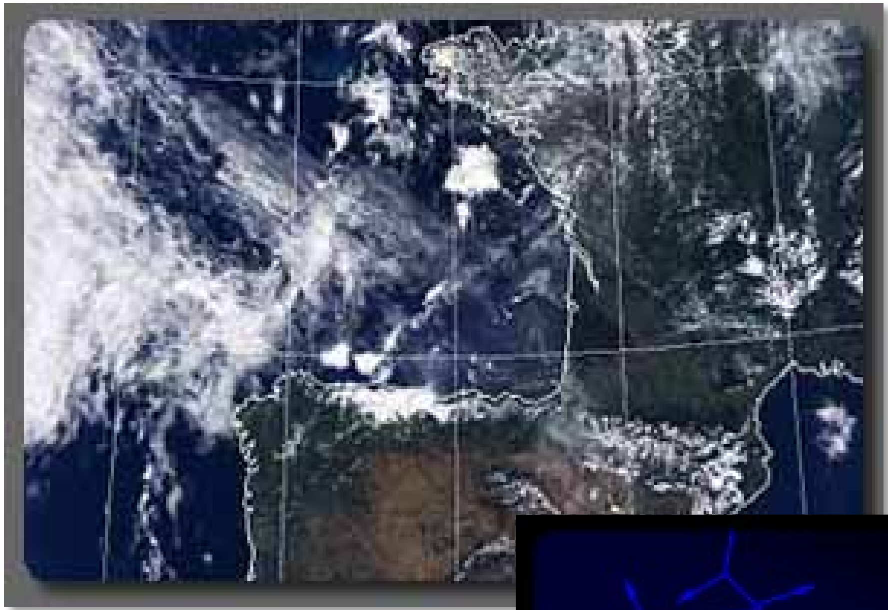
Figure 6.5a On the equinox, the sun's altitude (A) at solar noon at any place on earth is equal to 90 degrees minus the latitude (L).

HCL

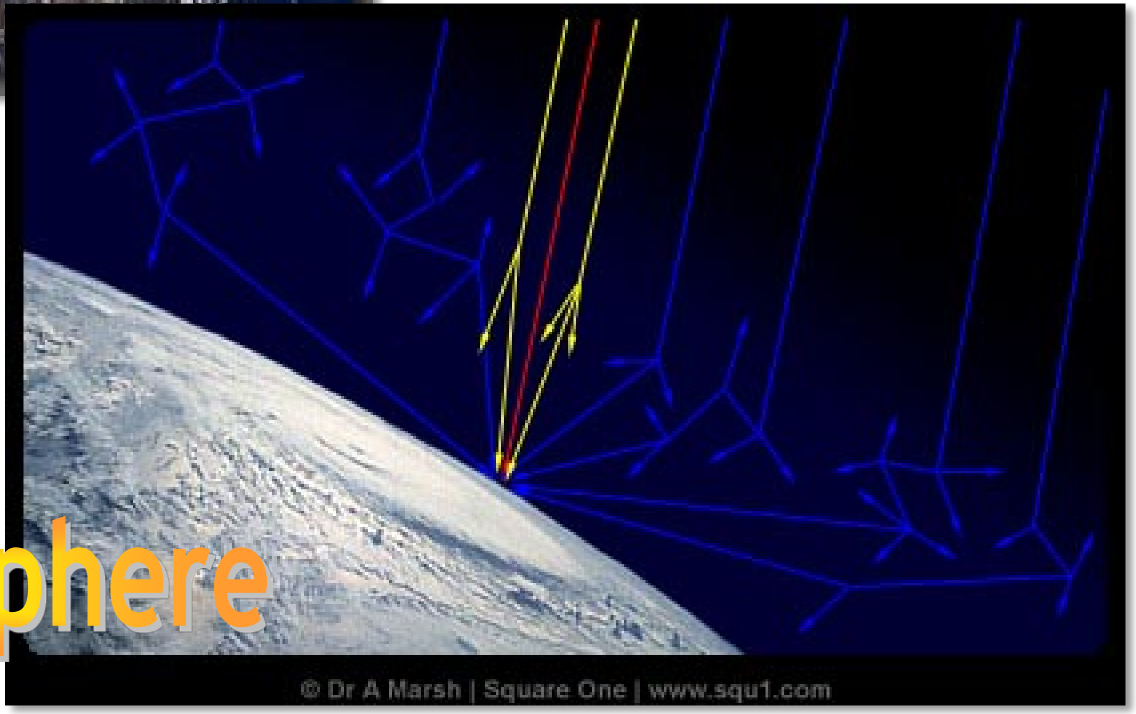
The vertical angle at which the sun's rays strike the earth is called the 'altitude angle', and is a function of latitude, time of year and time of day. The simplest situation occurs at 12 noon on the equinox, when the sun's rays are perpendicular to the earth at equator. Altitude Angle = 90^o - Latitude



Relation between declination, altitude angle, and latitude.

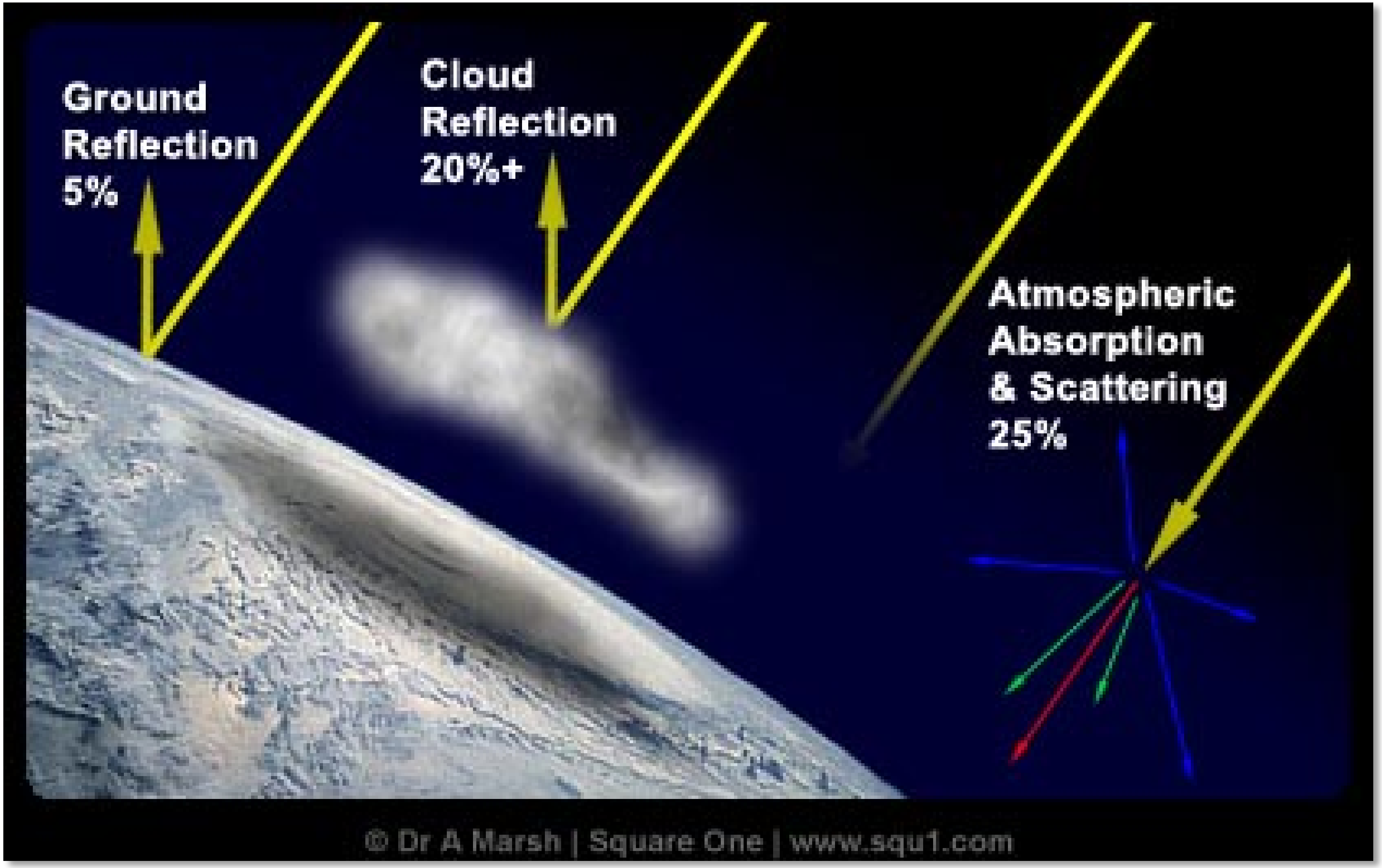


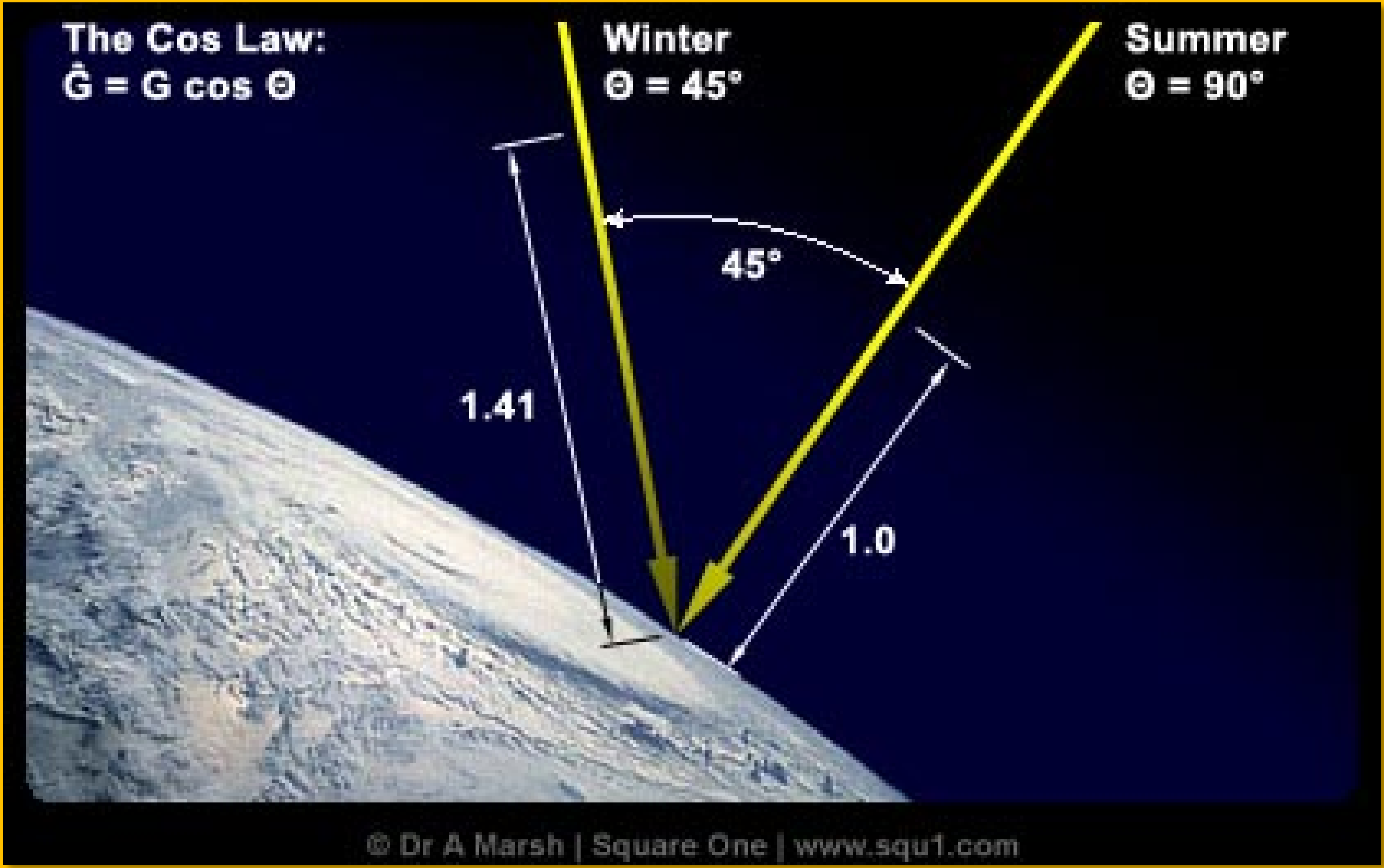
The exact nature of the solar radiation we receive is a function of our atmosphere.

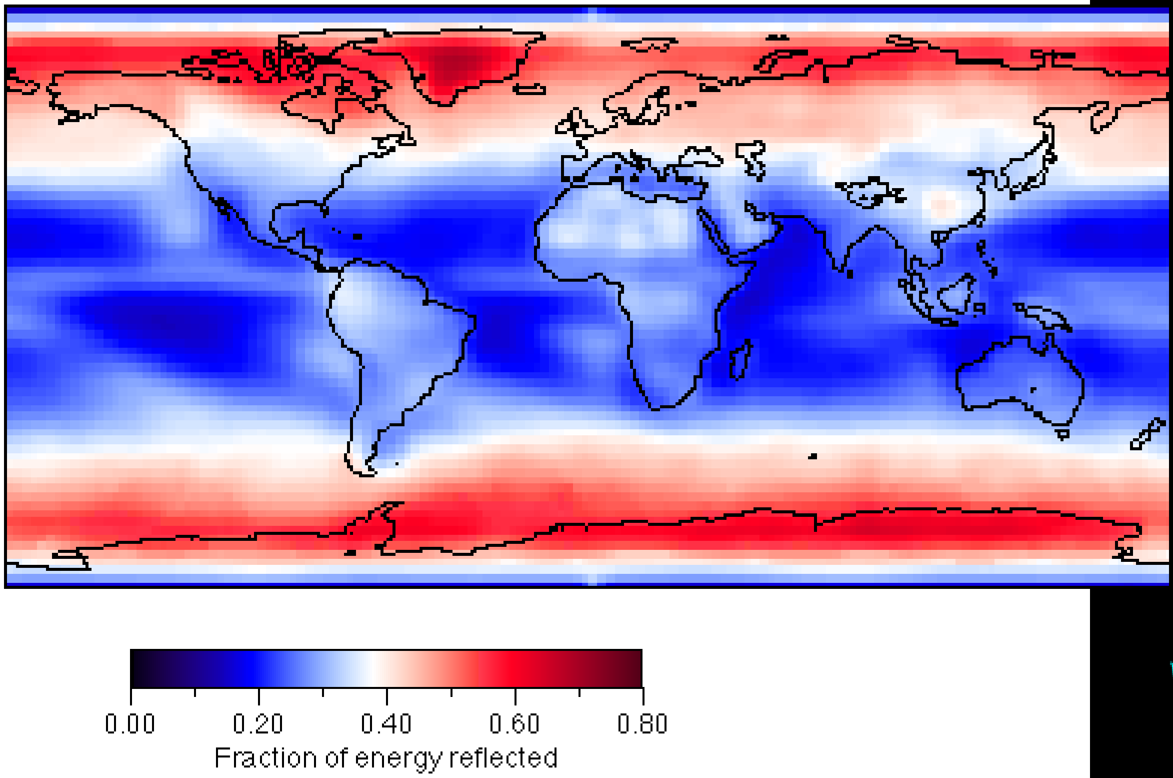


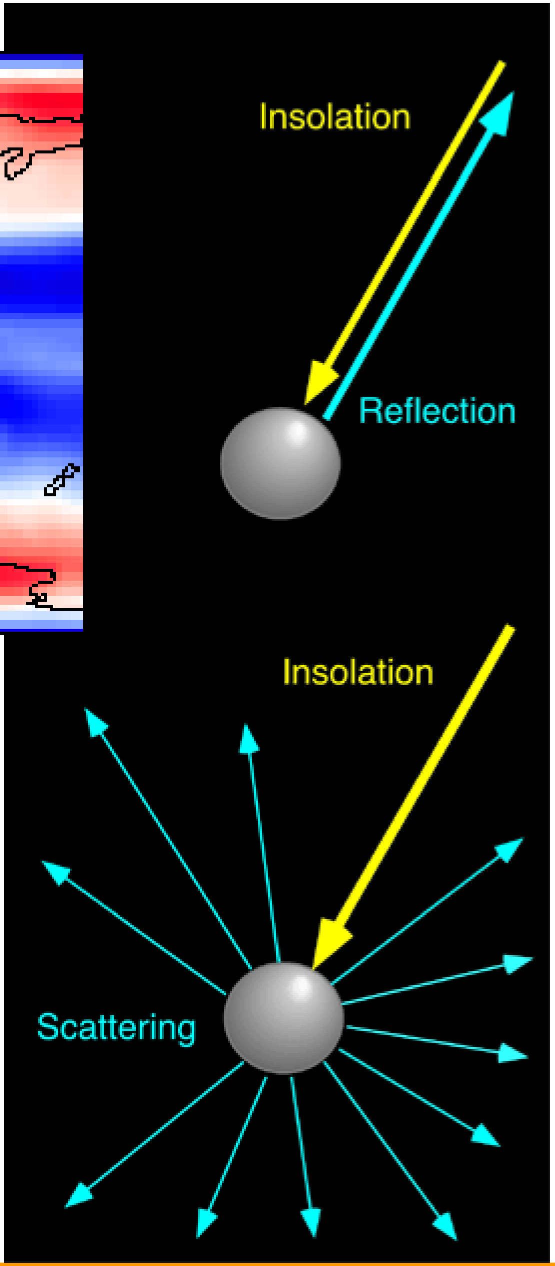
The Atmosphere

The Atmosphere




The Cos Law:
Ĝ = G cos Θ
Winter
Θ = 45°
Summer
Θ = 90°
45°
1.41
1.0
© Dr A Marsh | Square One | www.squ1.com





Not all solar radiation is absorbed by the earth - much is reflected and scattered. The image of the earth above shows more is collected where the sun passes through the atmosphere with less travel distance. It is also a function of cloud cover.

Part of the reason for the decrease in intensity in WINTER is the amount of radiation that is absorbed by the atmosphere during the longer trip through it by oblique rays.

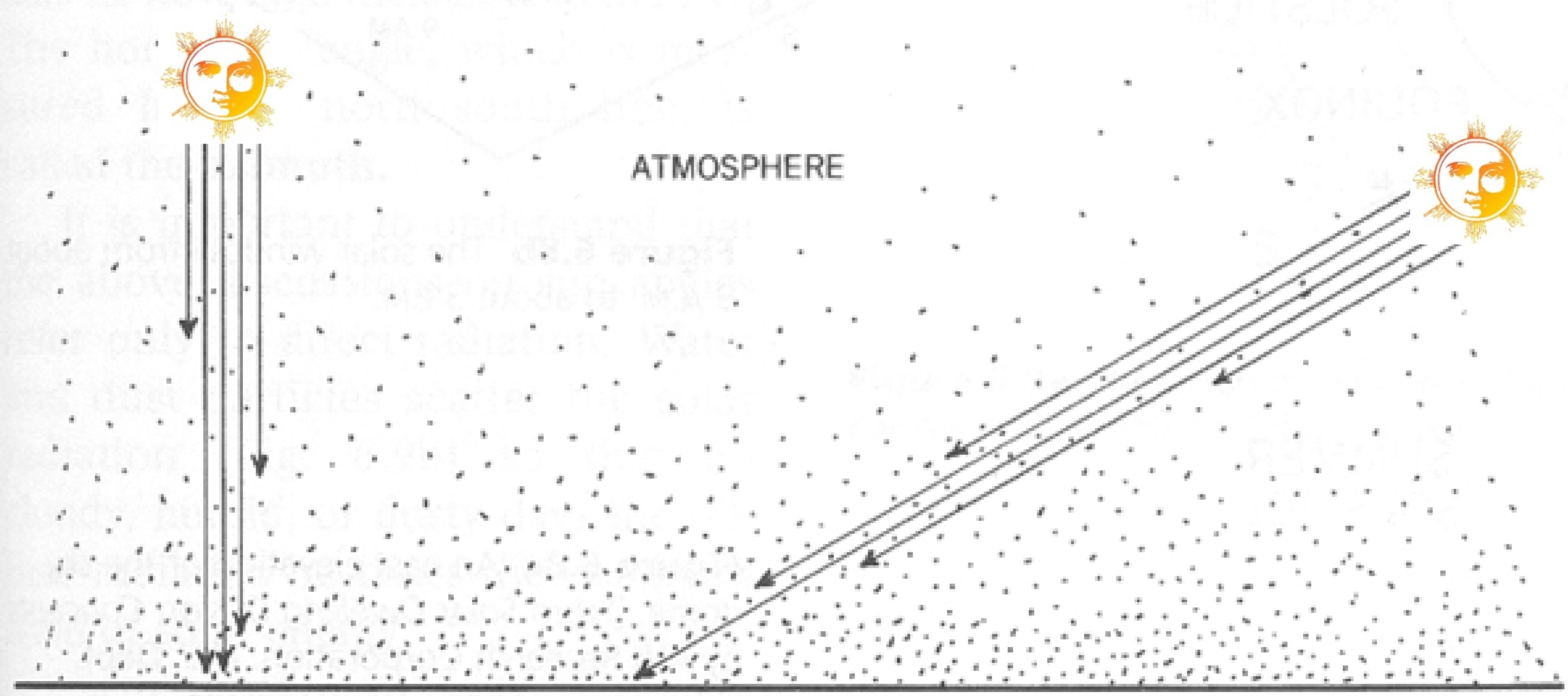


Figure 6.5b The altitude angle determines how much of the solar radiation will be absorbed by the atmosphere.

HCL

The angle the sun's rays make with the earth's surface also affects solar radiation levels. When the angle is oblique, the rays are less intense.

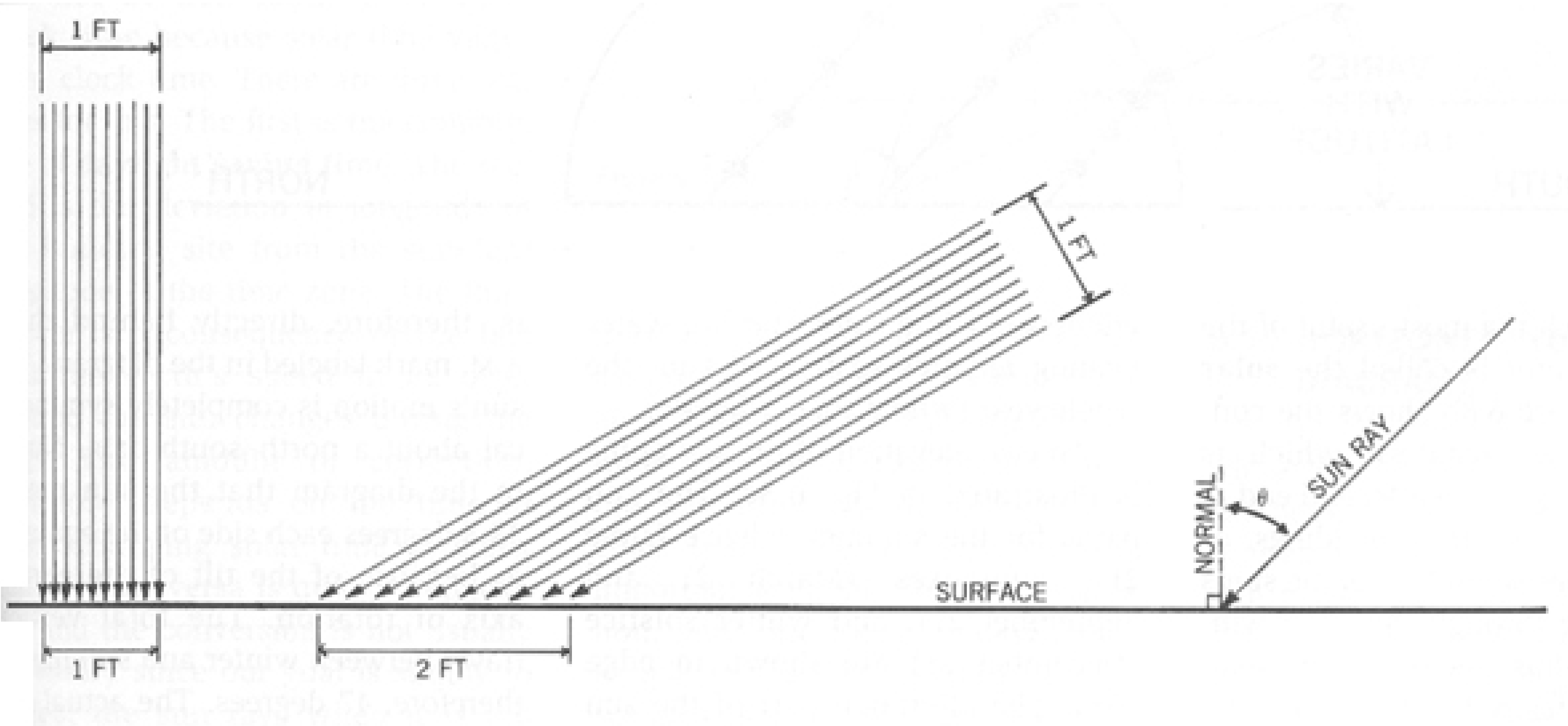


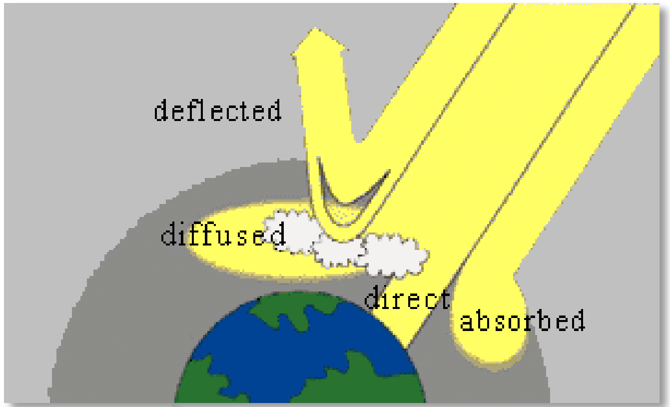
Figure 6.5c The cosine law states that the amount of radiation received by a surface decreases as the angle with the normal increases.

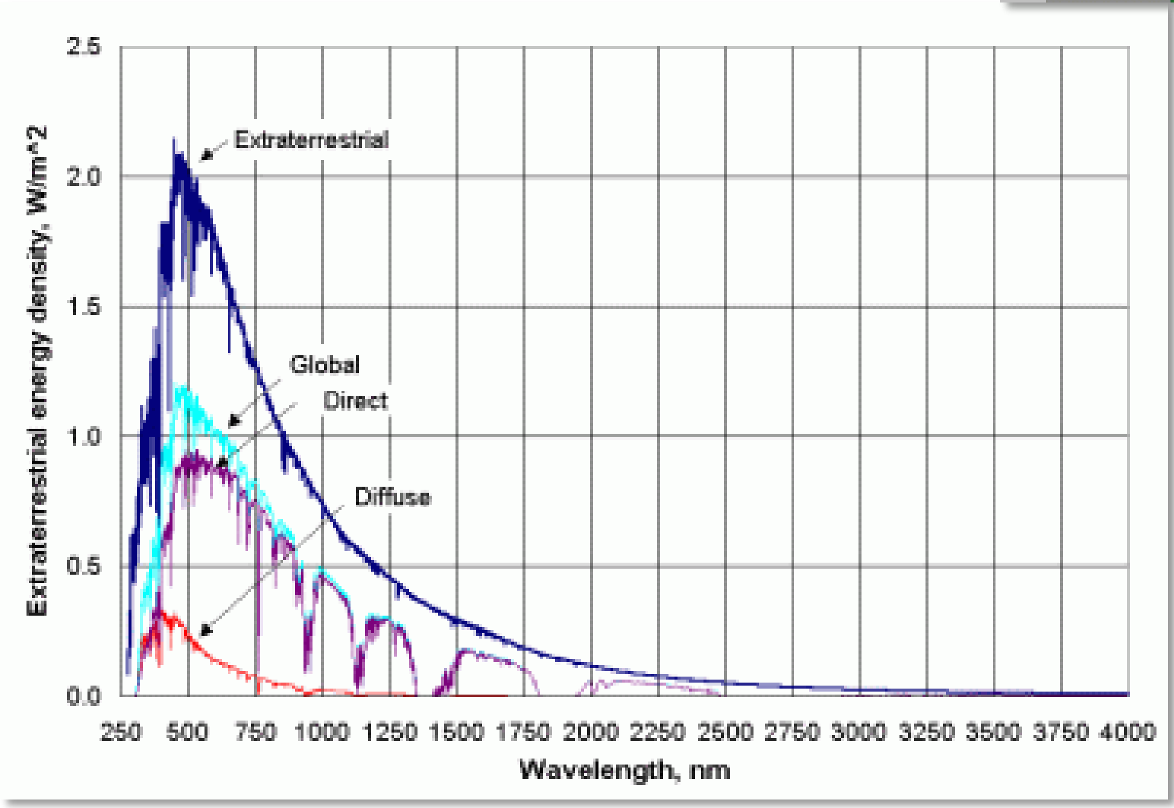
HCL

At low angles the sun's rays pass through more of the atmosphere – resulting in radiation reaching the surface being weaker –

i.e.: sunset

The wavelength of the light is also affected by its “clarity” and source.





Reasons for Winter

The temperature of the air, and land is primarily a result of the amount of solar radiation absorbed by land.

Reasons for less radiation are:

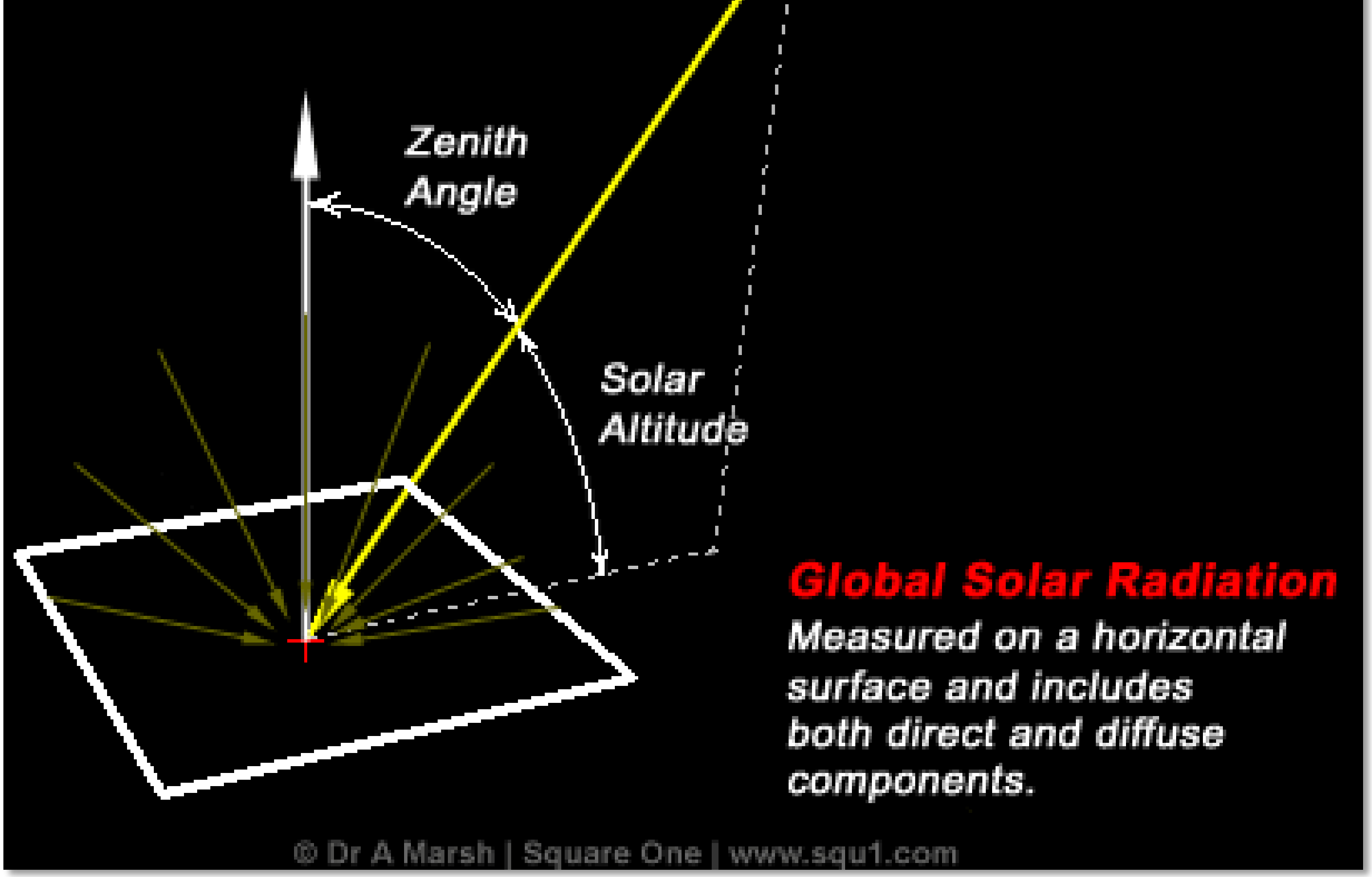
1. Far fewer hours of daylight (6 hrs less at 40 degrees latitude on December 21st than June 21st)
2. Reduced solar radiation due to cosine law.
3. Lower sun angles increase amount of atmosphere the sun must pass through to get here

Solar "Attitude"

Copernicus is credited with establishing that the earth orbits around the sun –

However for the purposes of building design let's again assume that the sun revolves around the earth, or at least that the sun revolves around the building site in question.

Solar Altitude



Solar Altitude

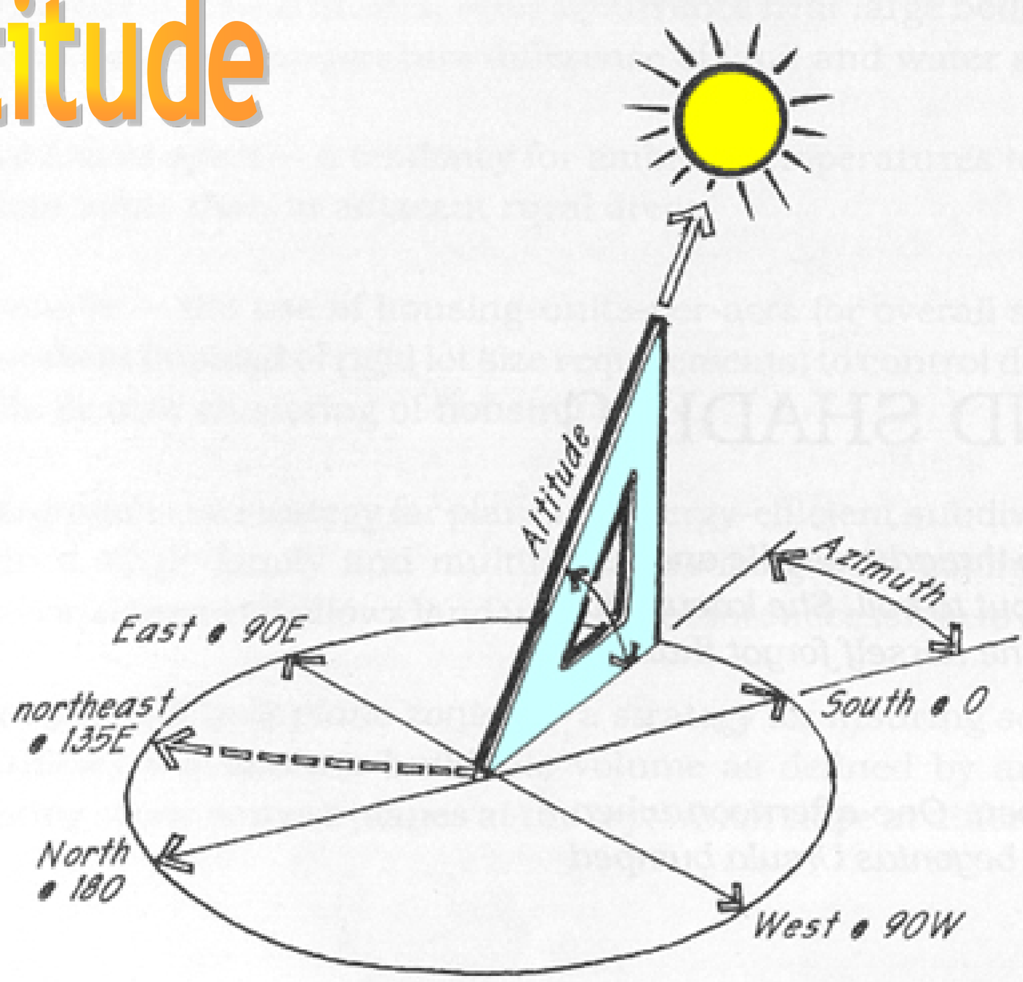
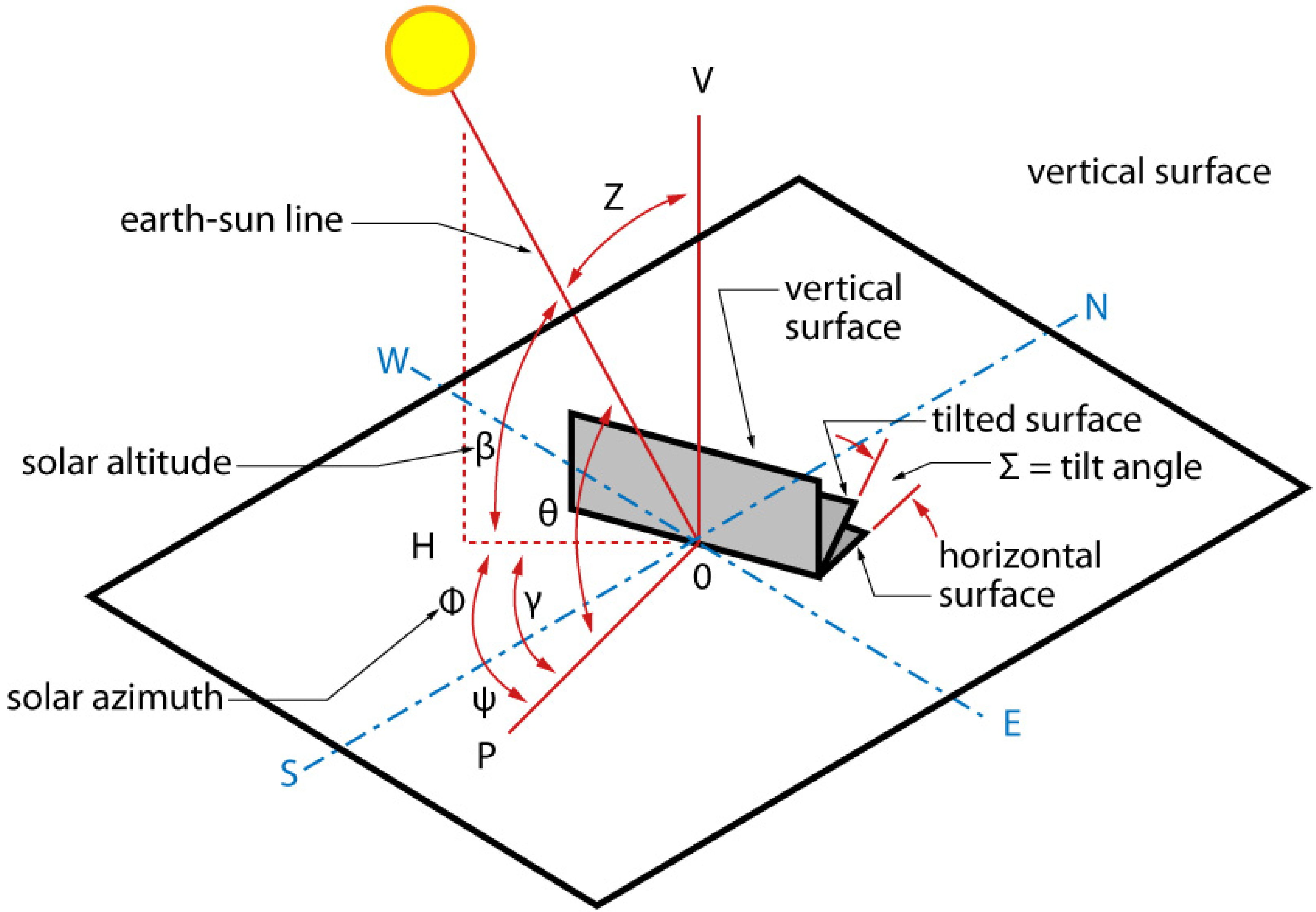


Figure 5.1: Solar azimuth and altitude angles. *Azimuth* angles are measured in each direction from south (for example, northeast = 135° E). *Altitude* angles are measured vertically from the horizon. *(Reproduced from Moore, 1985, by permission.)*

HCL



V
vertical surface
Z
earth-sun line
vertical
surface
N
W
tilted surface
Σ = tilt angle
solar altitude
β
θ
H
0
horizontal
surface
Φ
γ
solar azimuth
ψ
E
S
P

Sky Dome


12
10
4
12
6
4
10
6
2
12
4
10
8
6
Summer
Solstice
Equinox
Winter
Solstice

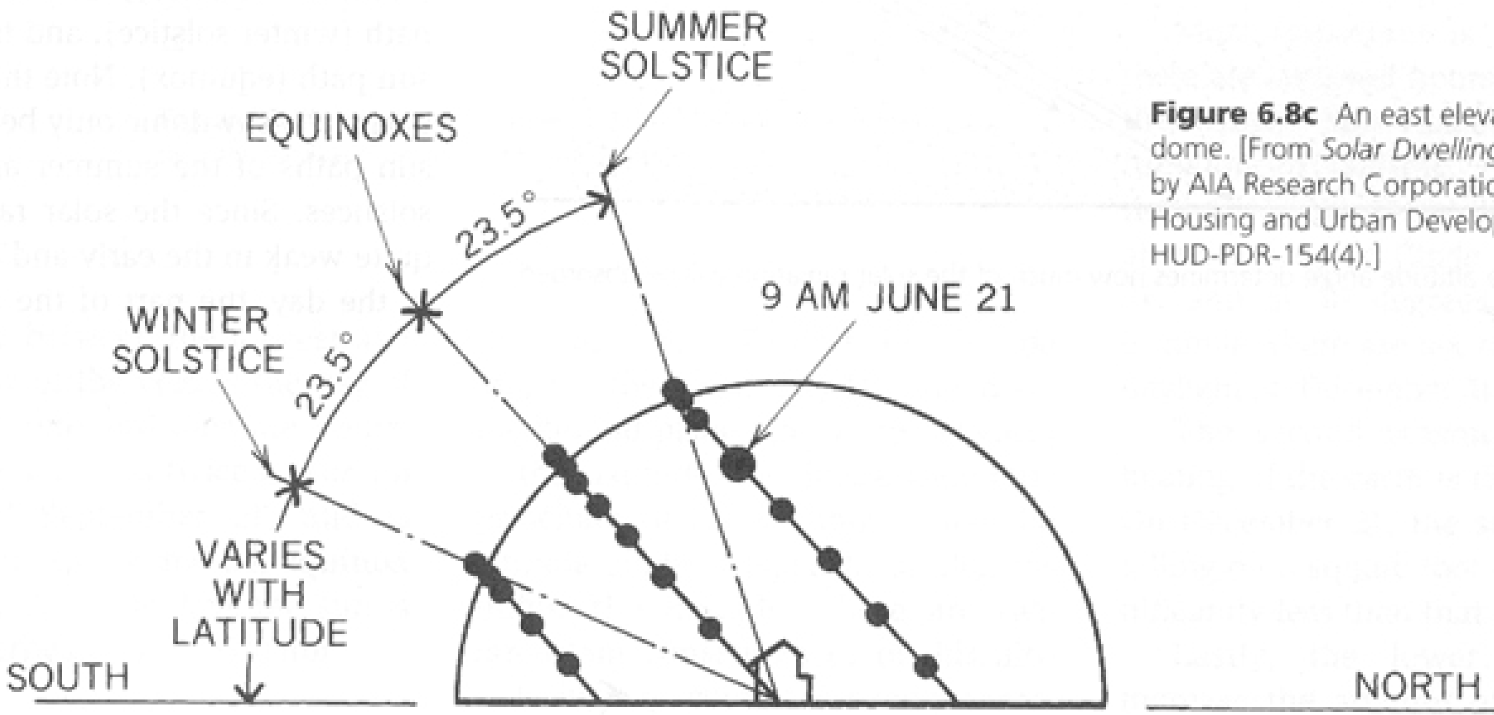


Figure 6.8c An east elevation of the sky dome. [From *Solar Dwelling Design Concepts* by AIA Research Corporation. U.S. Dept. Housing and Urban Development, 1976. HUD-PDR-154(4).]

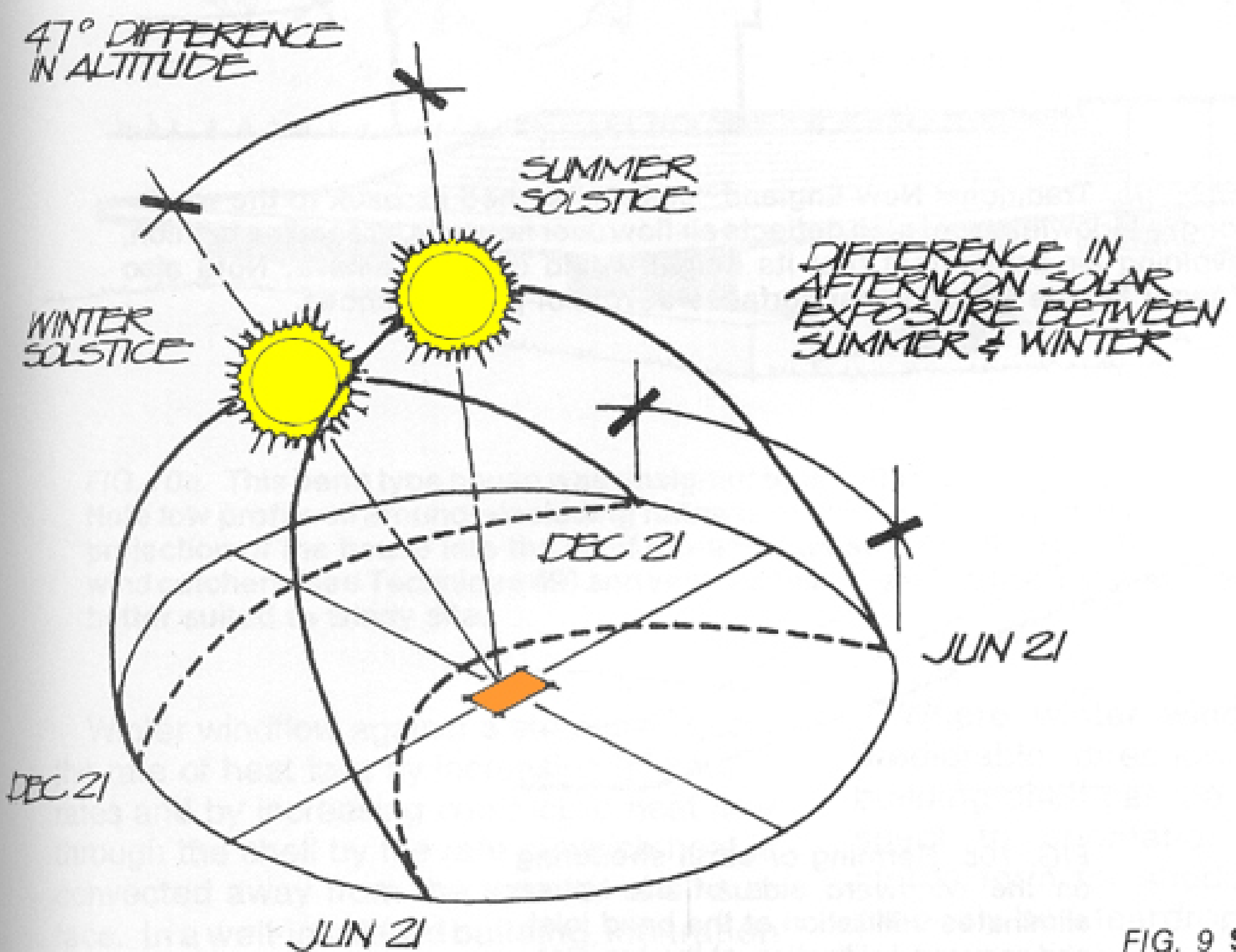


FIG. 9 Sunpath diagram illustrates that the only meaningful orientation for winter sun exposure is south. In summer, east and west exposures are the worst villains for overheating.

CBD

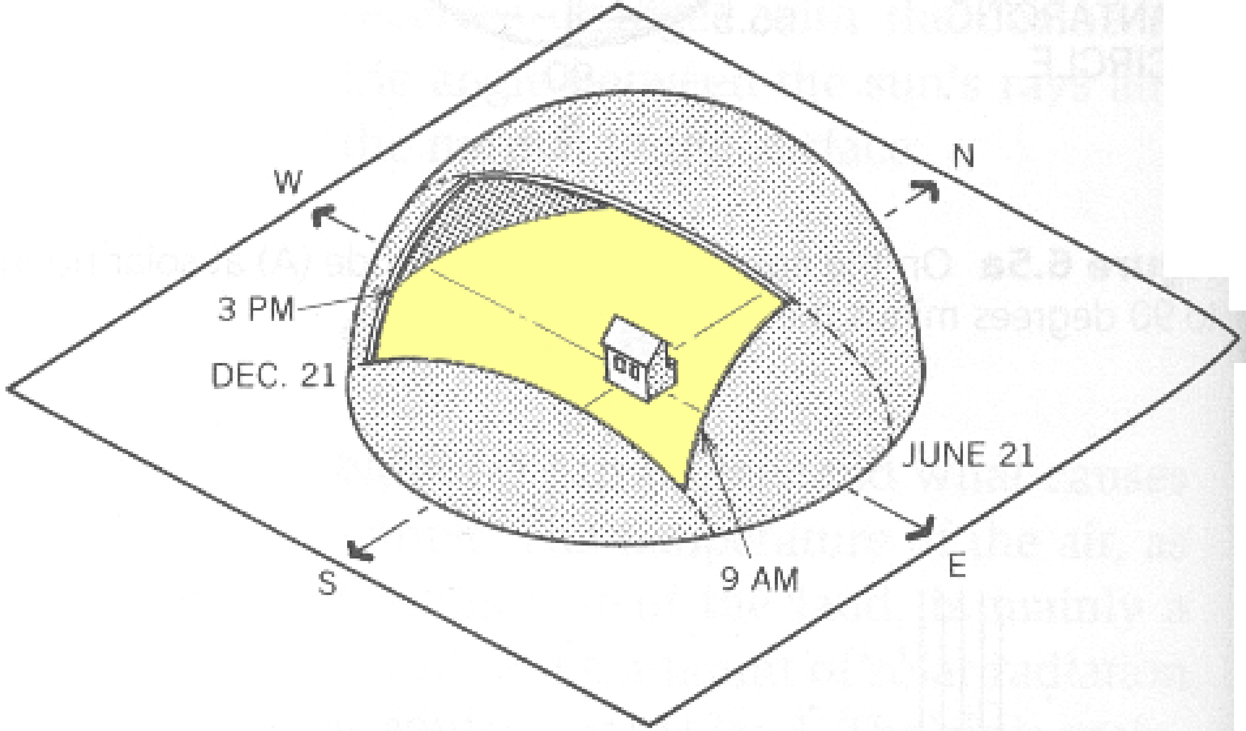
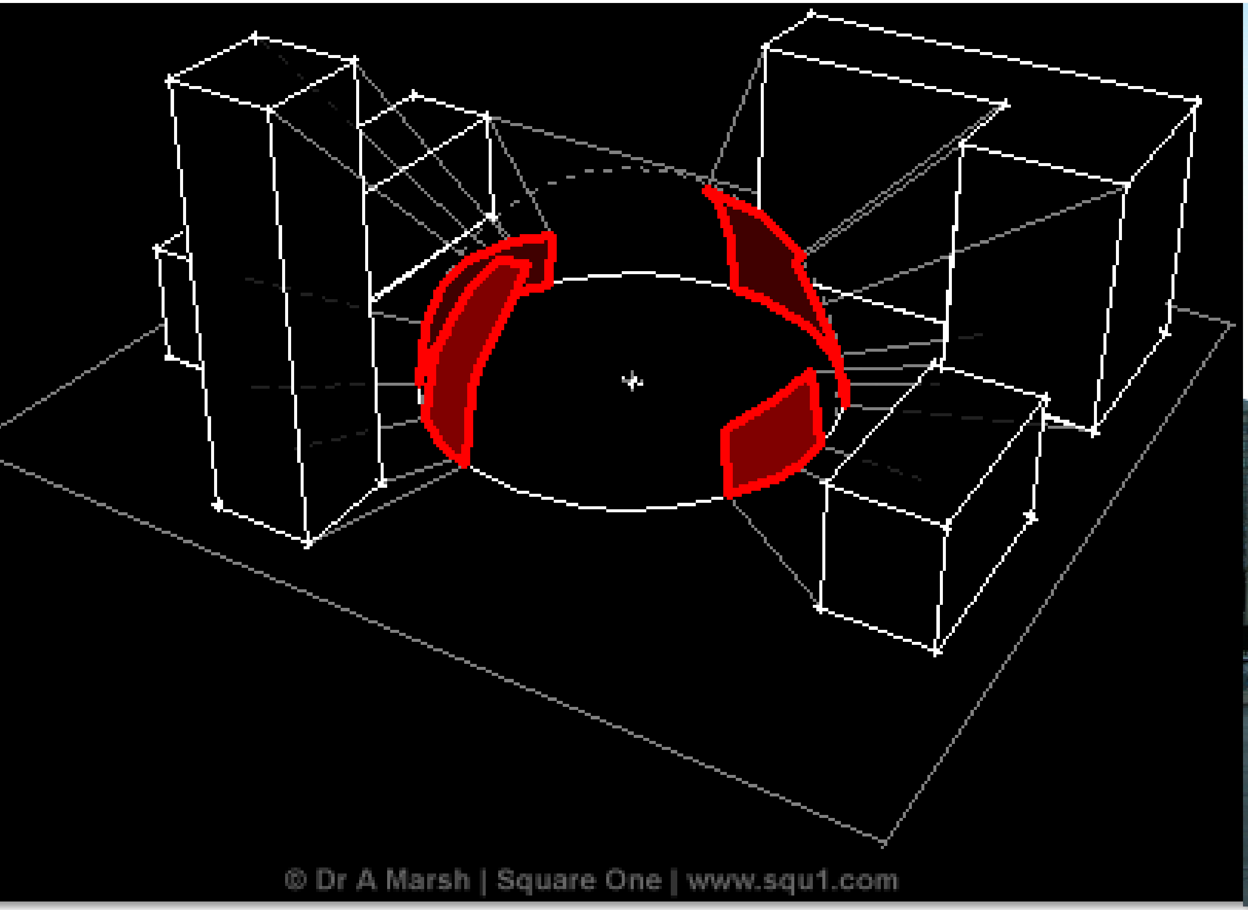


Figure 6.8b The solar window from about 9 A.M. to about 3 P.M.

HCL

- Space Heating - lower half of solar window, mostly desired in winter only
- Domestic Hot Water Heating - all year round

Surrounding buildings affect the view from the site to the sky.



As well as cast shadows on the site.

Derivation of Sun Path Diagrams

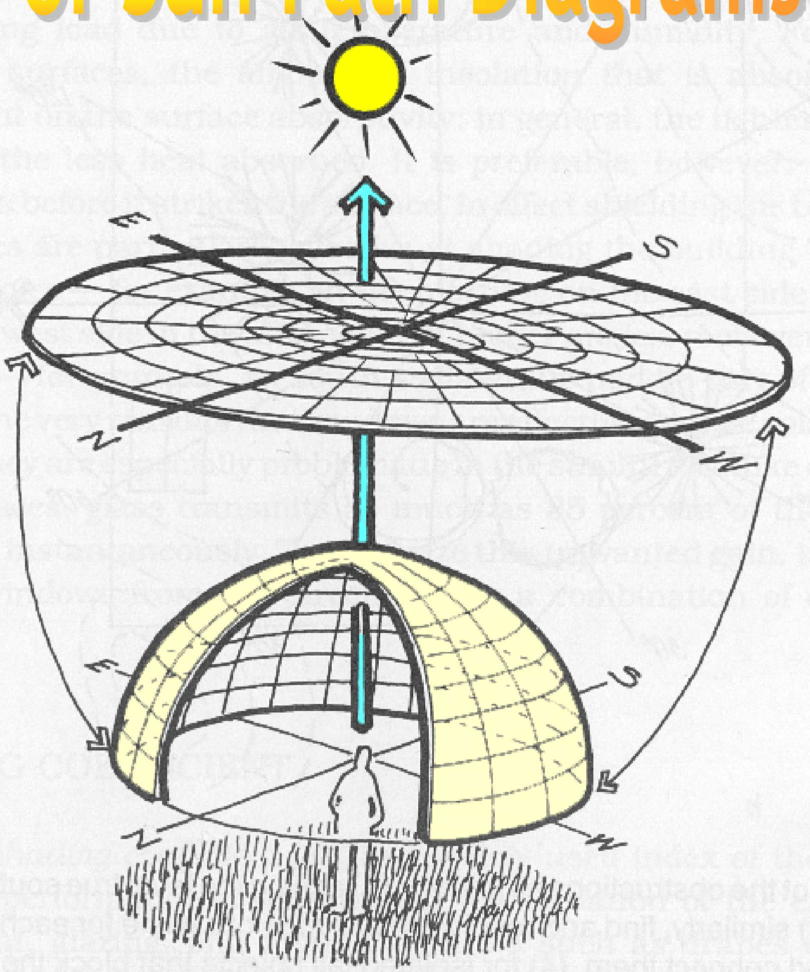


Figure 5.8: Sky dome, with equidistant plan projection showing azimuth and altitude coordinates. *(Reproduced from Moore, 1985, by permission.)*

HCL

Horizontal Projection Sun Path Diagram

Vertical Projection Sun Path Diagram

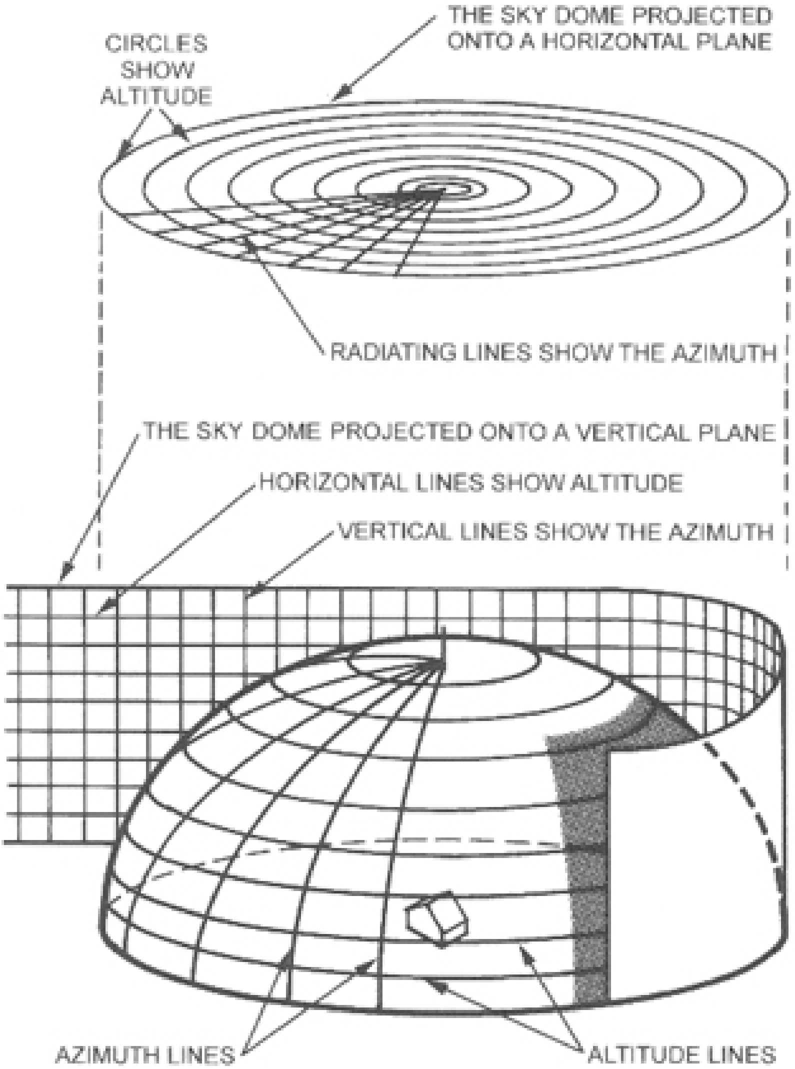


Figure 6.11a Derivation of the horizontal and vertical sun path diagrams.

HCL

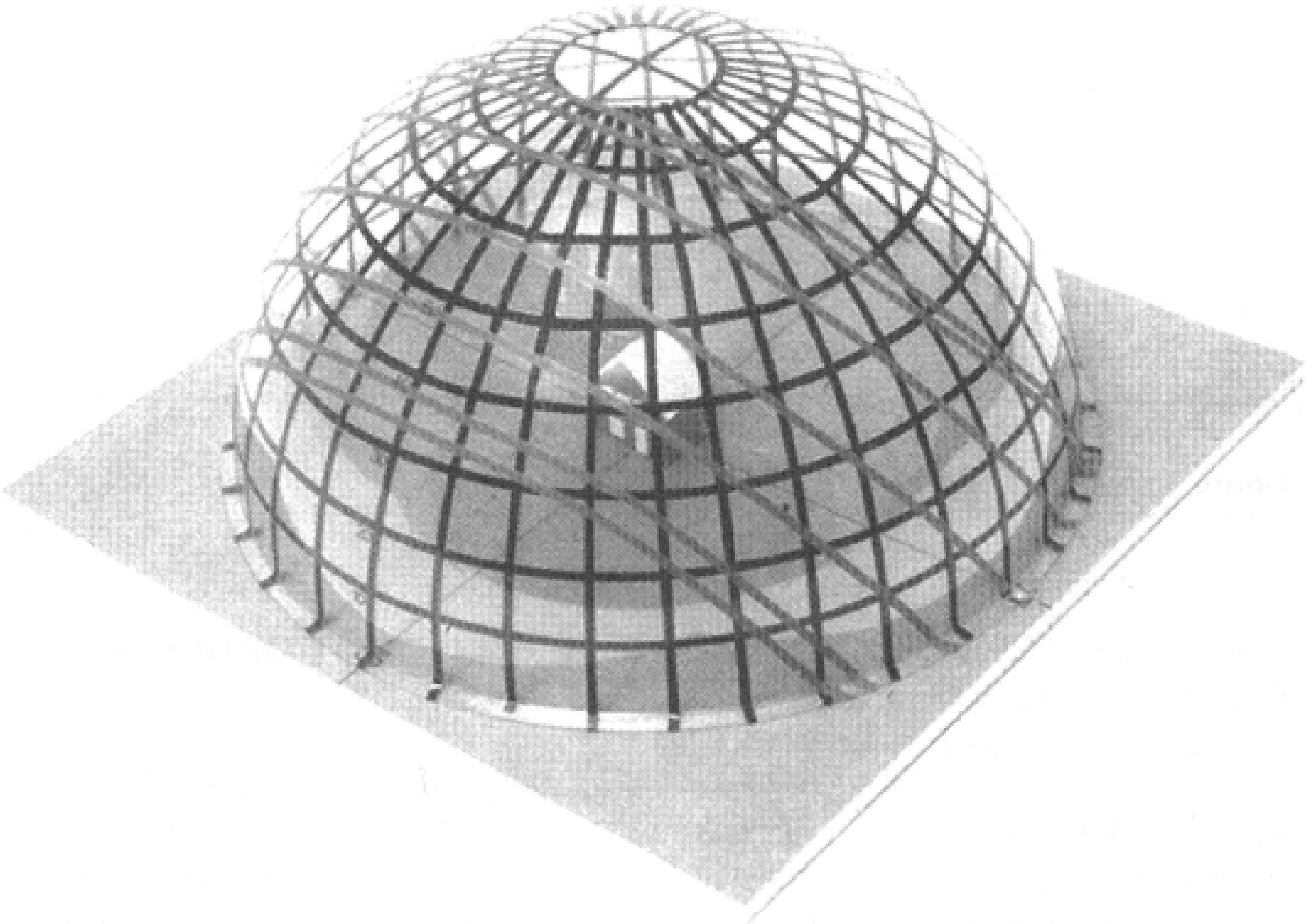
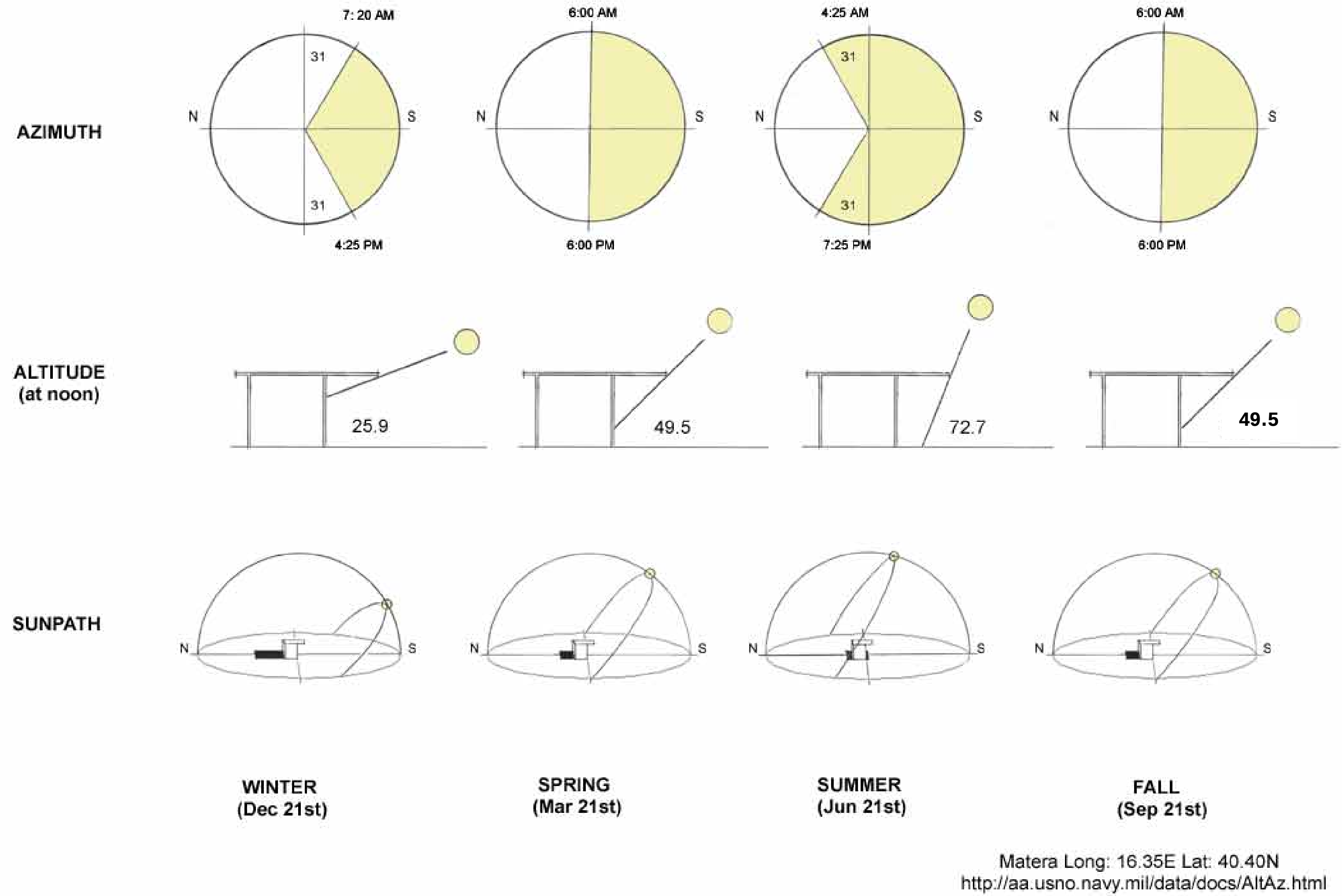
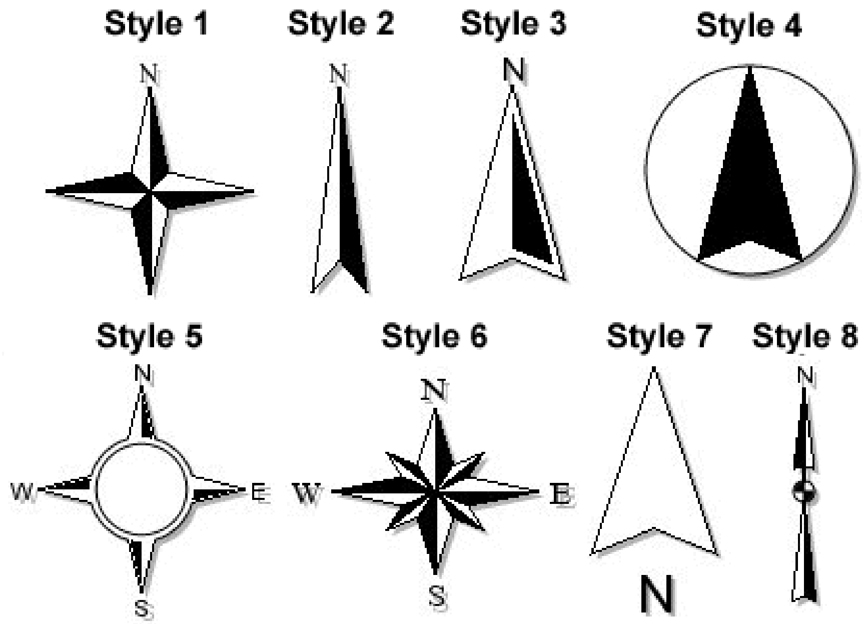


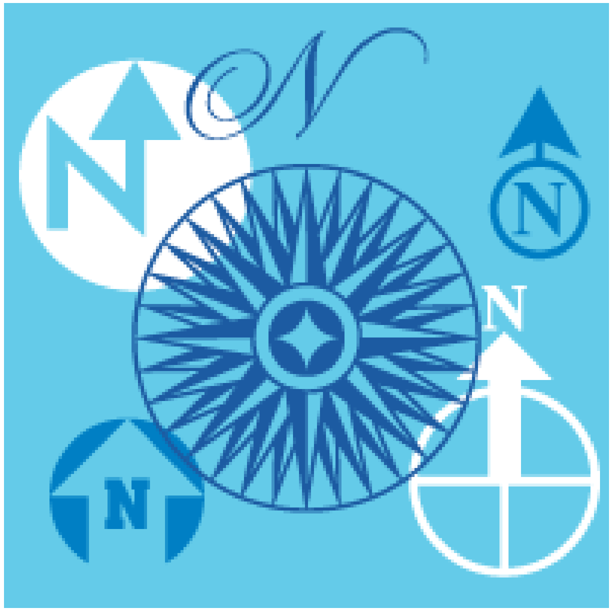
Figure 6.11b A model of the sky dome. The sun paths for the 21st day of each month are shown. Only seven paths are needed for twelve months because of symmetry (i.e., May 21 is the same path as July 21.

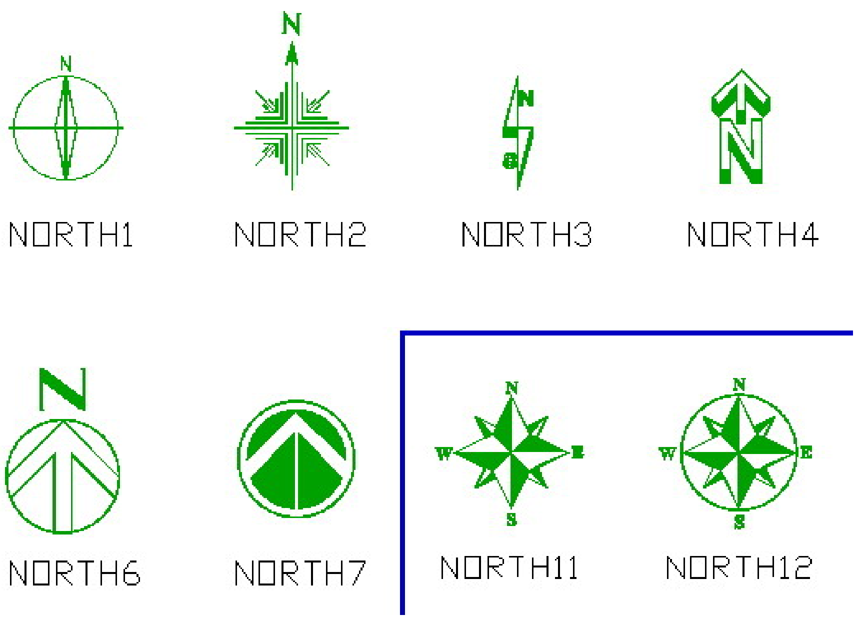
HCL



You should be able to construct this set of diagrams for *any site* you are working on.

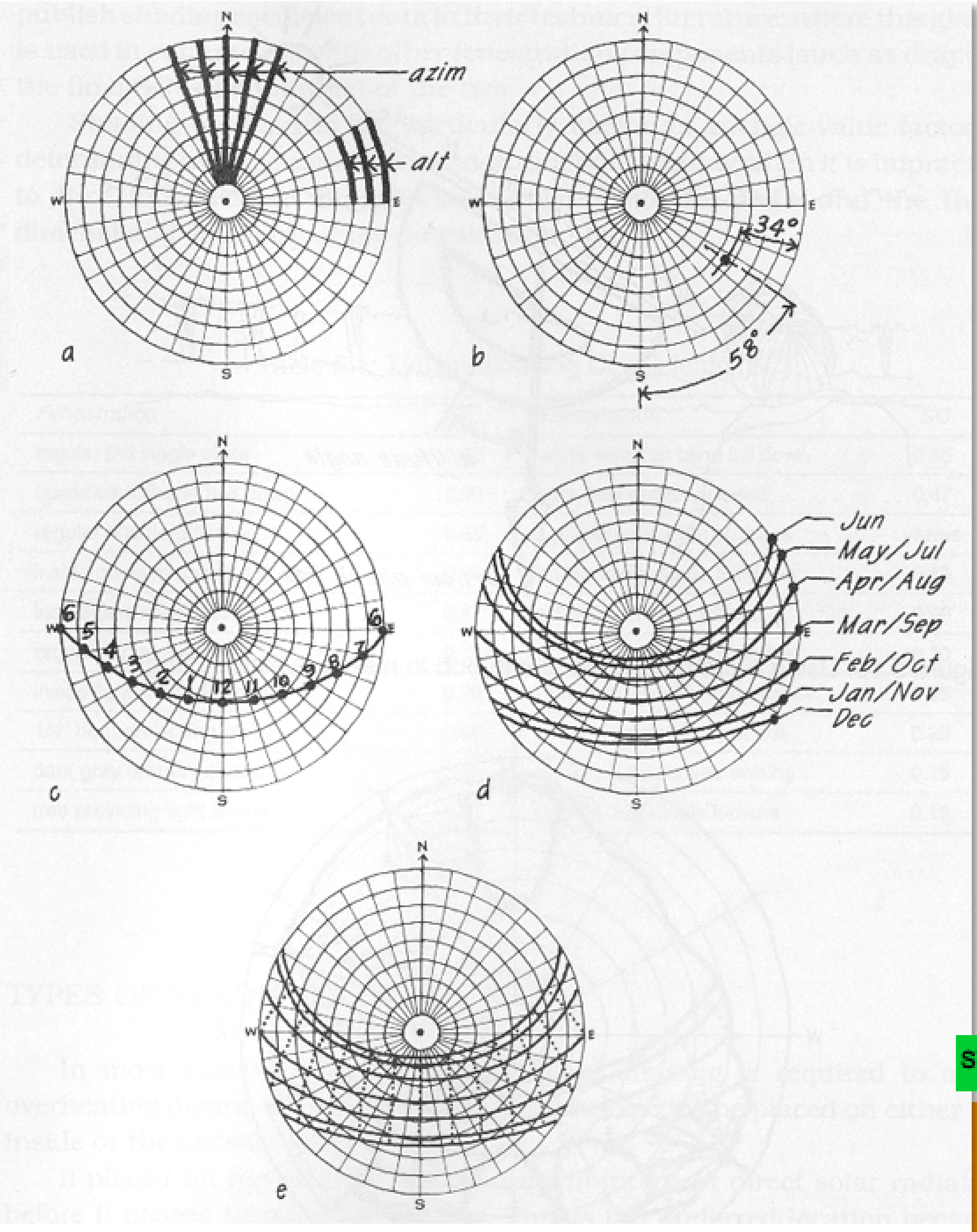






Designing for solar conditions requires that you are aware of the orientation of the site. If you don’t have one of these on your plan *from the beginning*, then, *you are not aware.*

Sun Path Diagrams



SWL

These are “aerial plan views” of the skydome.

Notice that the sun is symmetrical about the solstices, so we get the same lines for the spring and fall months.

Horizontal Projection Sun Path Diagram

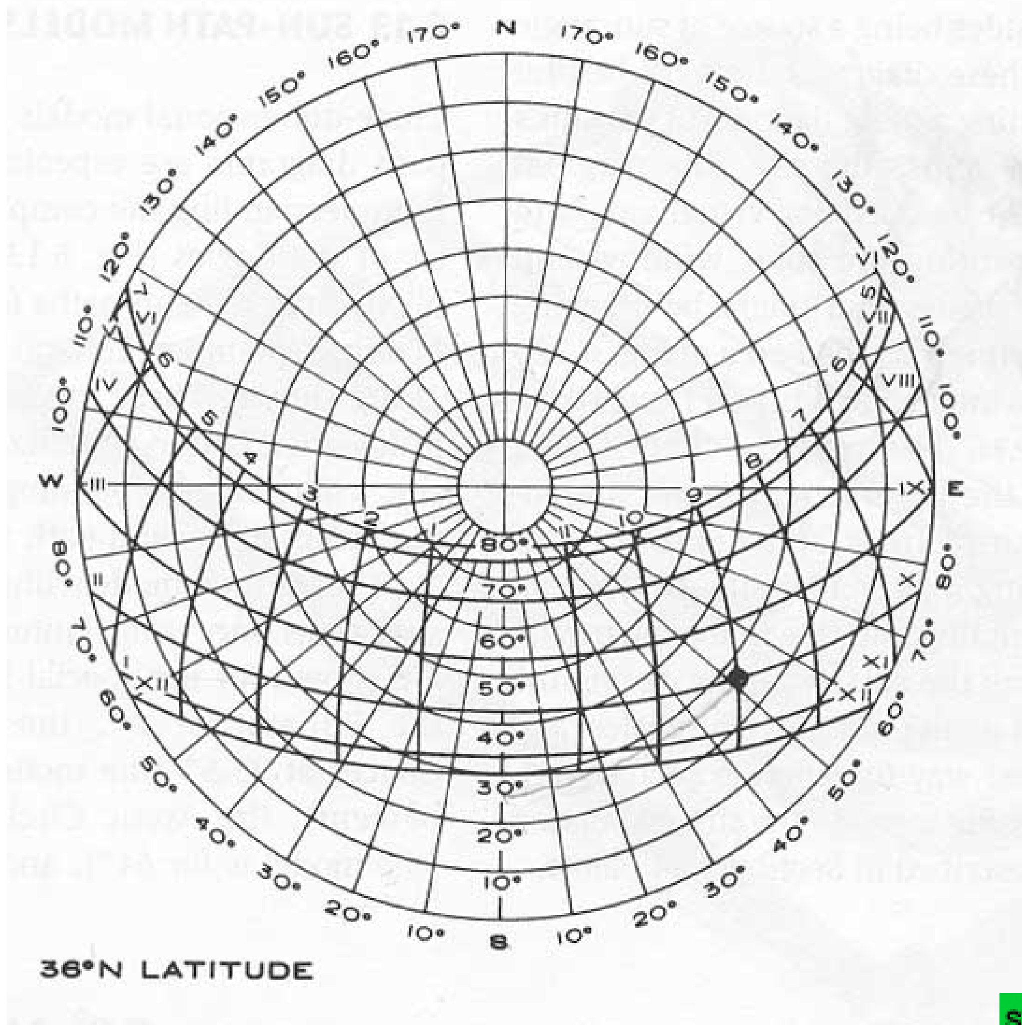
Example: Find the altitude and azimuth of the sun in Memphis, Tennessee, on February 21 at 9 A.M.

Step 1. From a map of the United States, find the latitude of Memphis. Since it is at about 35 degrees latitude, use the sun-path diagram for 36 degrees north latitude (found in Appendix A and Fig. 6.11c).

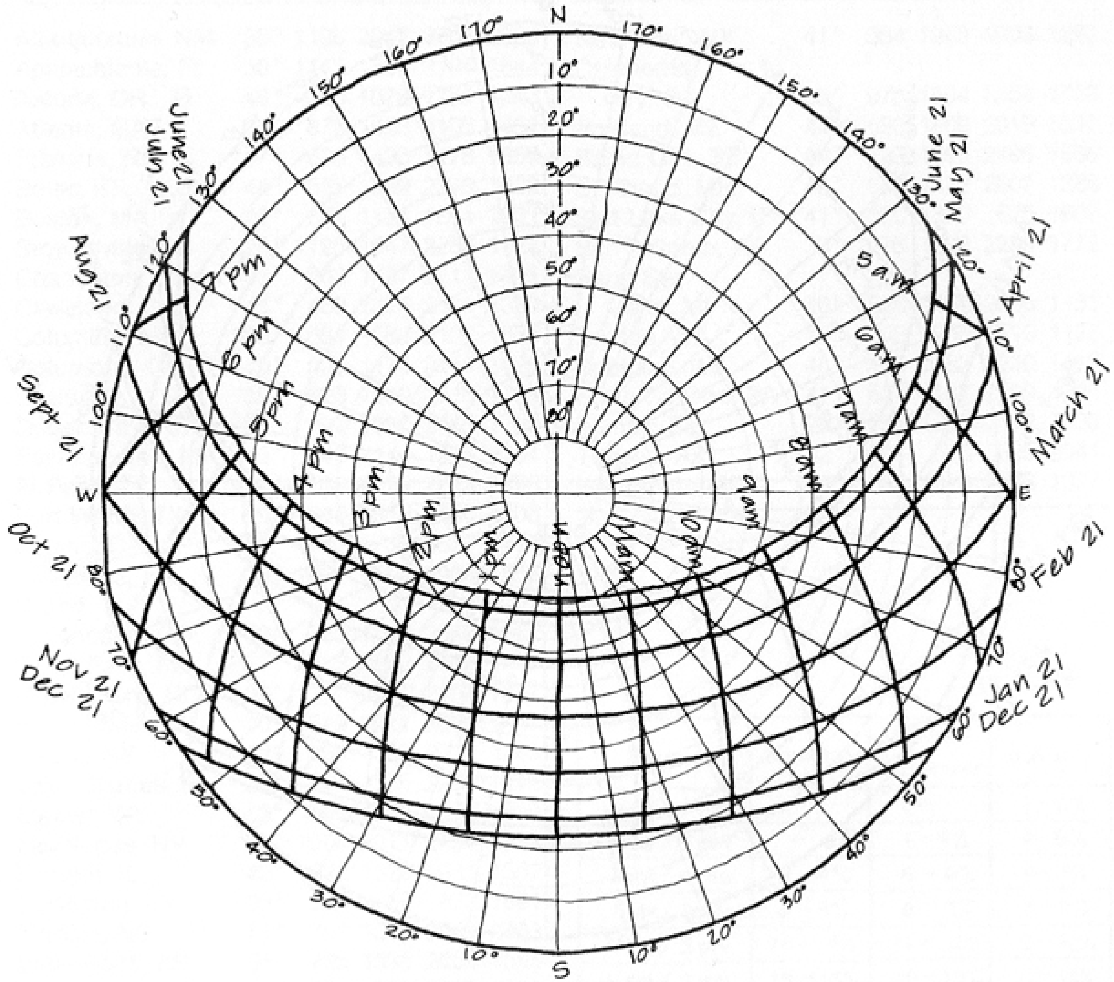
Step 2. On this sun-path diagram, find the intersection of the sun path for February 21 (curve II) and the 9 A.M. line. This represents the location of the sun. The intersection is circled in Fig. 6.11c.

Step 3. From the concentric circles, the altitude is found to be about 27 degrees.

Step 4. From the radial lines, the azimuth is found to be about 51 degrees east of south.



These diagrams always use "solar noon" as 12:00. You need to look at the local time conditions to see how this aligns to the actual time.

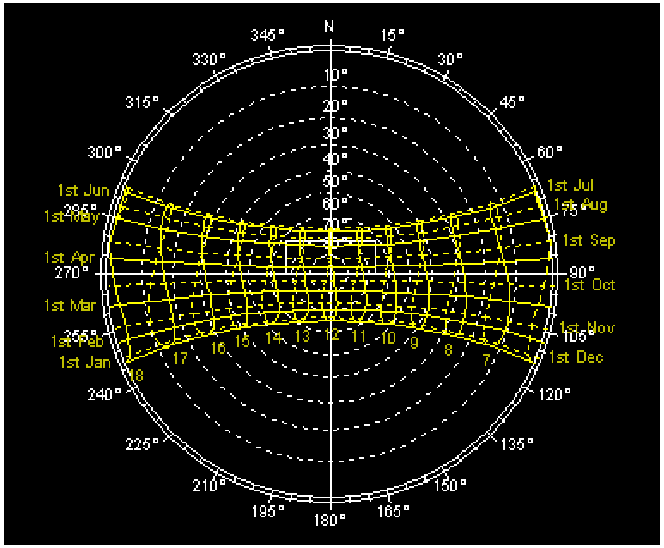


Sun Path Diagram 44° North Latitude

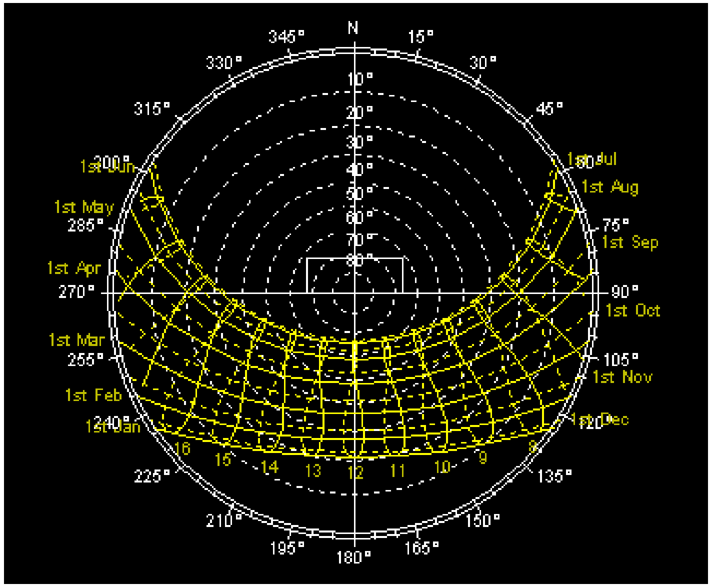
SWL

Toronto Latitude: 43° 40‘ North

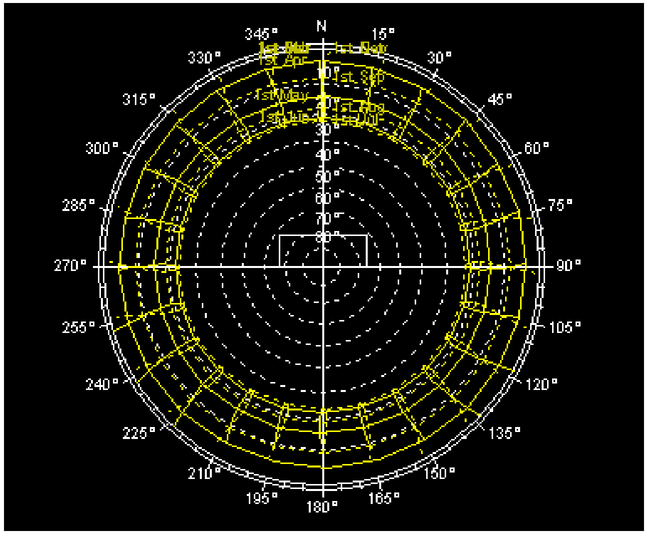
Kitchener Latitude: 43° 27‘ North



Equator



45 degrees N



North Pole

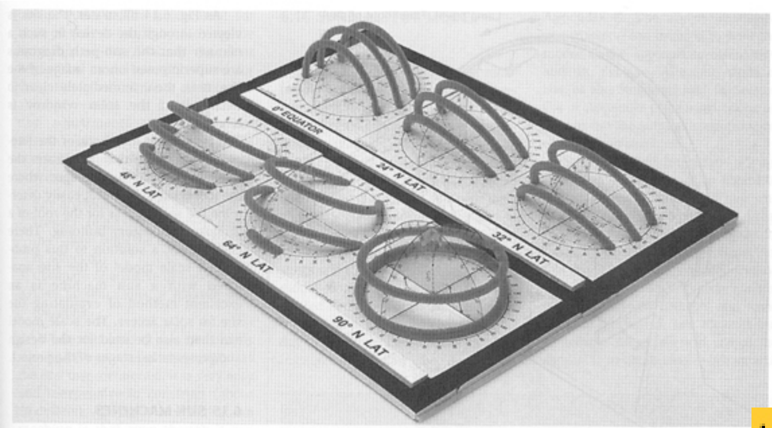


Figure 6.13 A comparison of various sun-path models. Note especially the sun paths for the Equator, Tropic of Cancer, Arctic Circle, and North Pole.

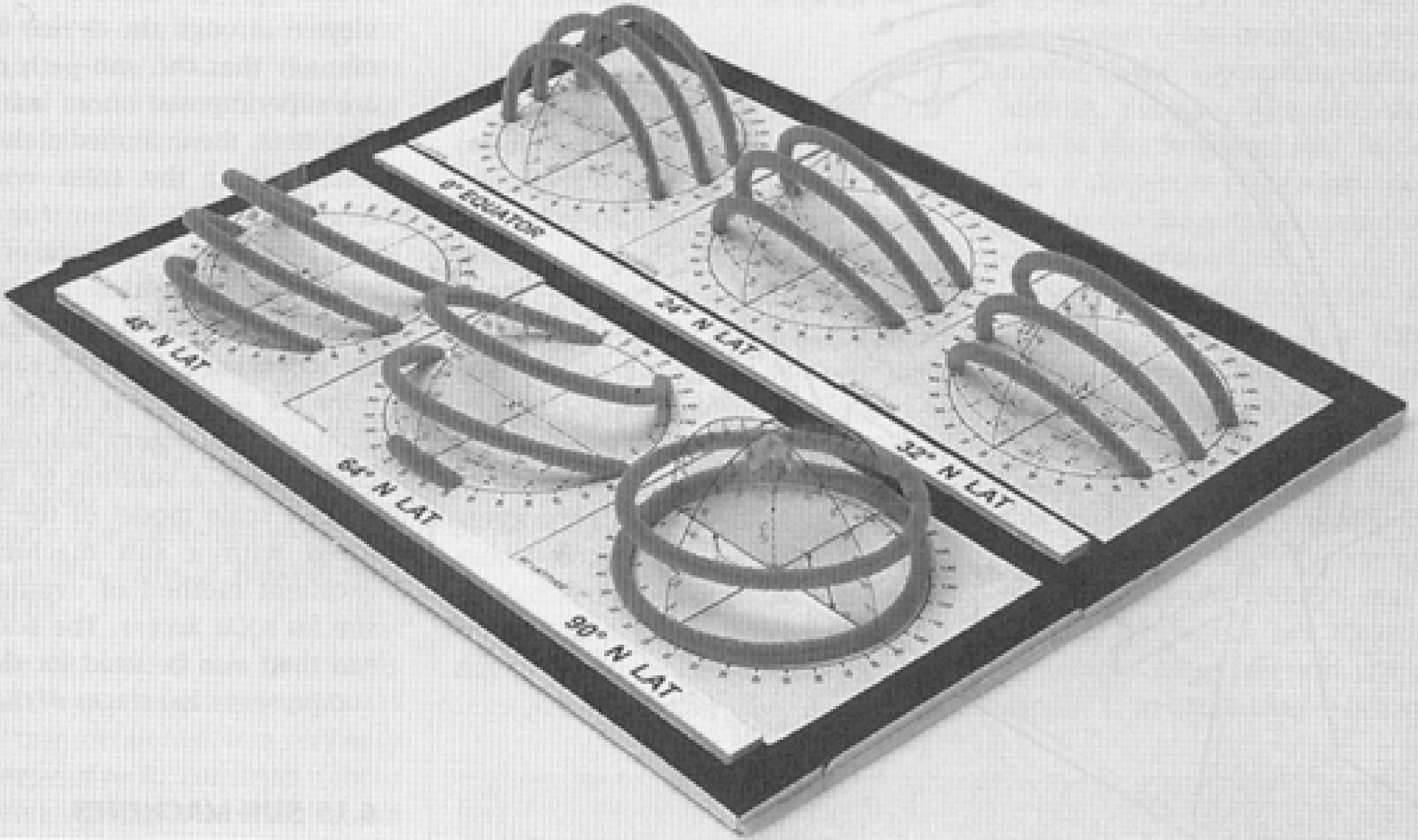


Figure 6.13 A comparison of various sun-path models. Note especially the sun paths for the Equator, Tropic of Cancer, Arctic Circle, and North Pole.

HCL

Vertical Projection Sun Path Diagram

Example: Find the altitude and azimuth of a sun ray in Albuquerque, New Mexico, on March 21 at 3 P.M.

Step 1. From Appendix B, choose the sun-path diagram that is within 2 degrees of the place in question. Since Albuquerque is at 35°N latitude, use the sun path for 36°N.

Step 2. Find the intersection of the curves for March 21 and 3 P.M. (see circle in Fig. 6.12a).

Step 3. From the horizontal scale, the azimuth is found to be about 59° *west* of south.

Step 4. From the vertical scale, the altitude is found to be about 34° above the horizontal.

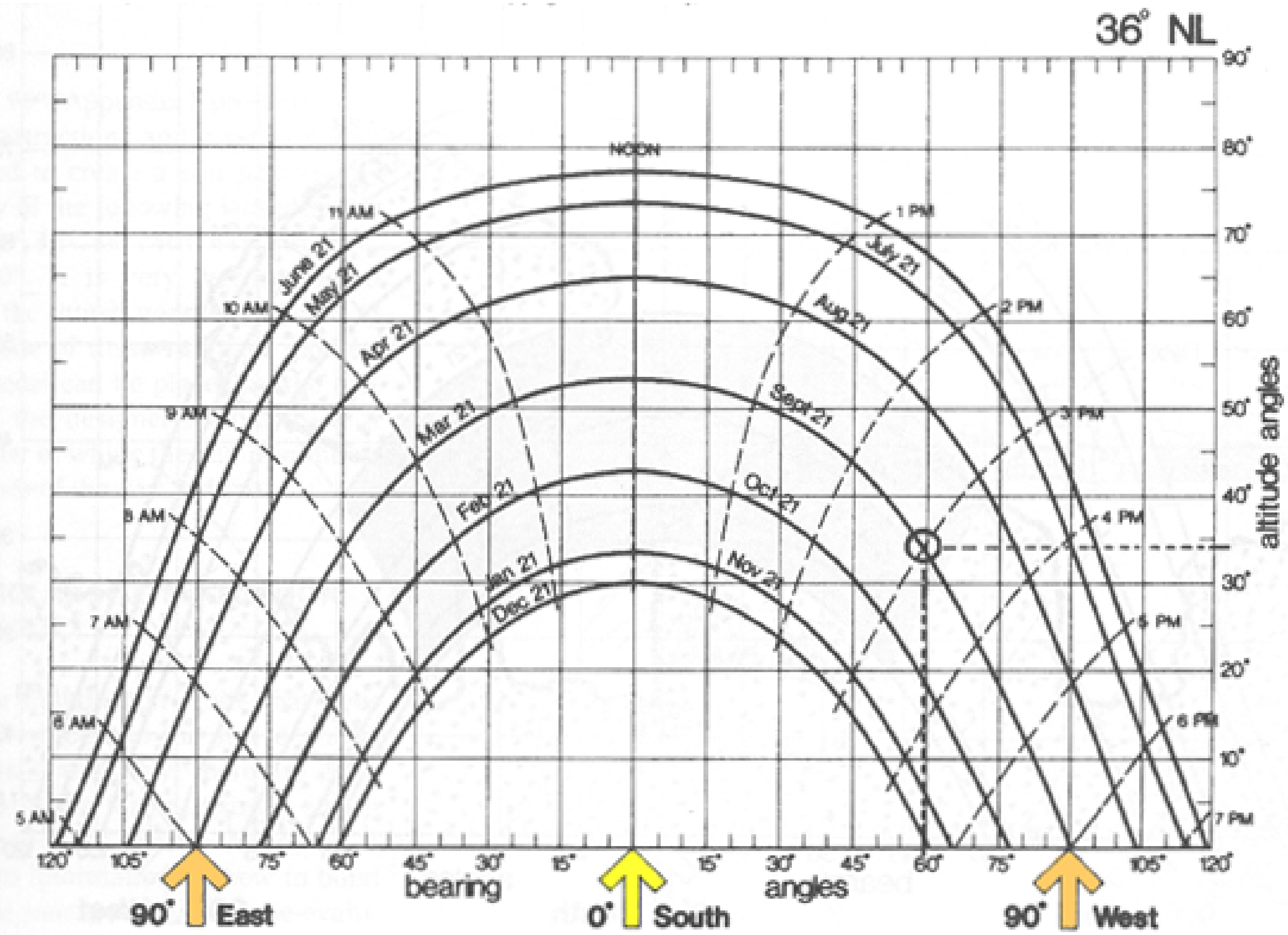


Figure 6.12a Vertical sun path diagram. A complete set of these diagrams is found in Appendix B. (Reprinted from *The Passive Solar Energy Book*, copyright E. Mazria, 1979, by permission.)

HCL

We use this tool to understand how surrounding buildings and trees will shade our site at various times of the year.

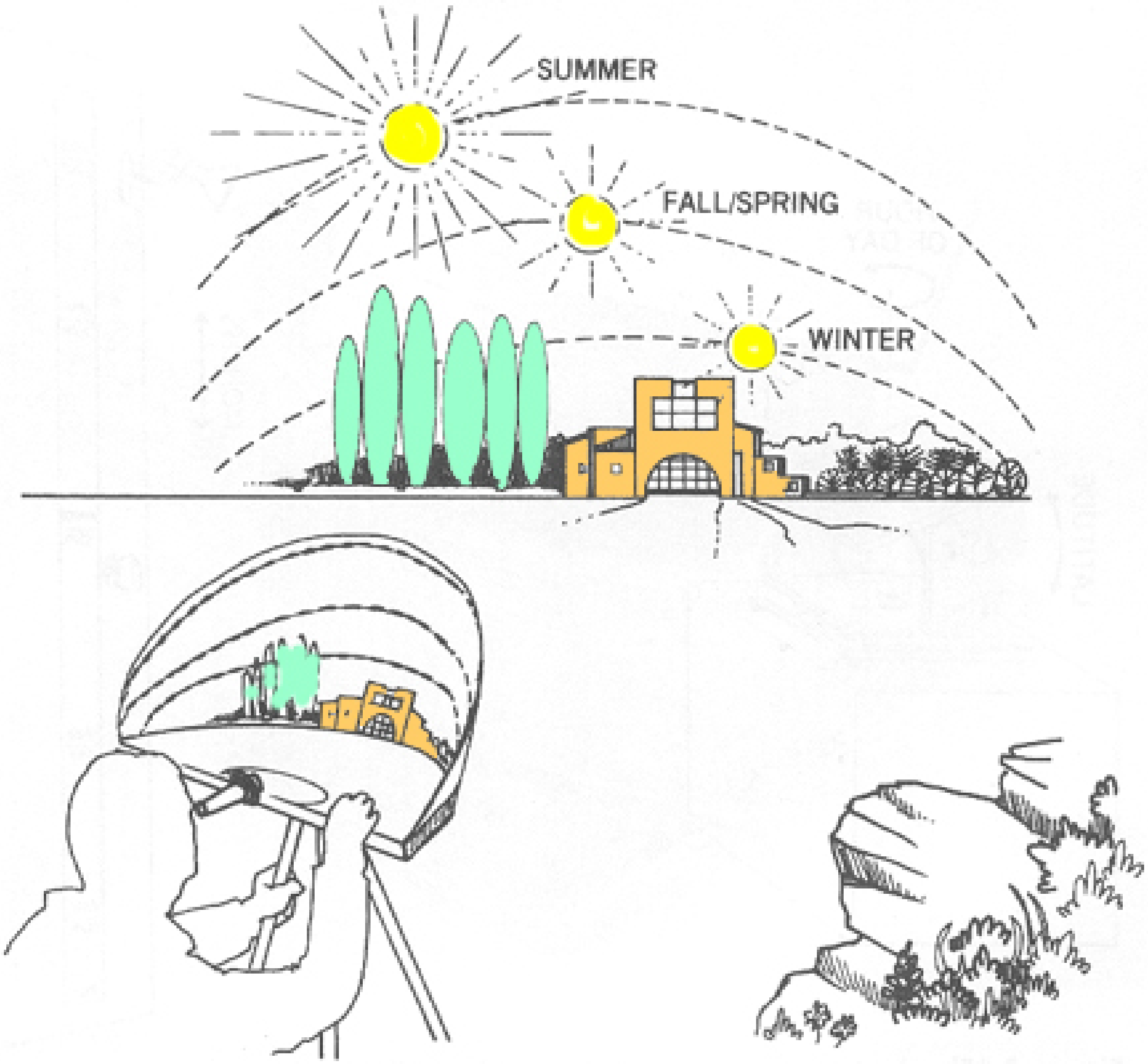


Figure 6.14 The sun-path diagram used as part of a solar site-evaluation tool.

HCL

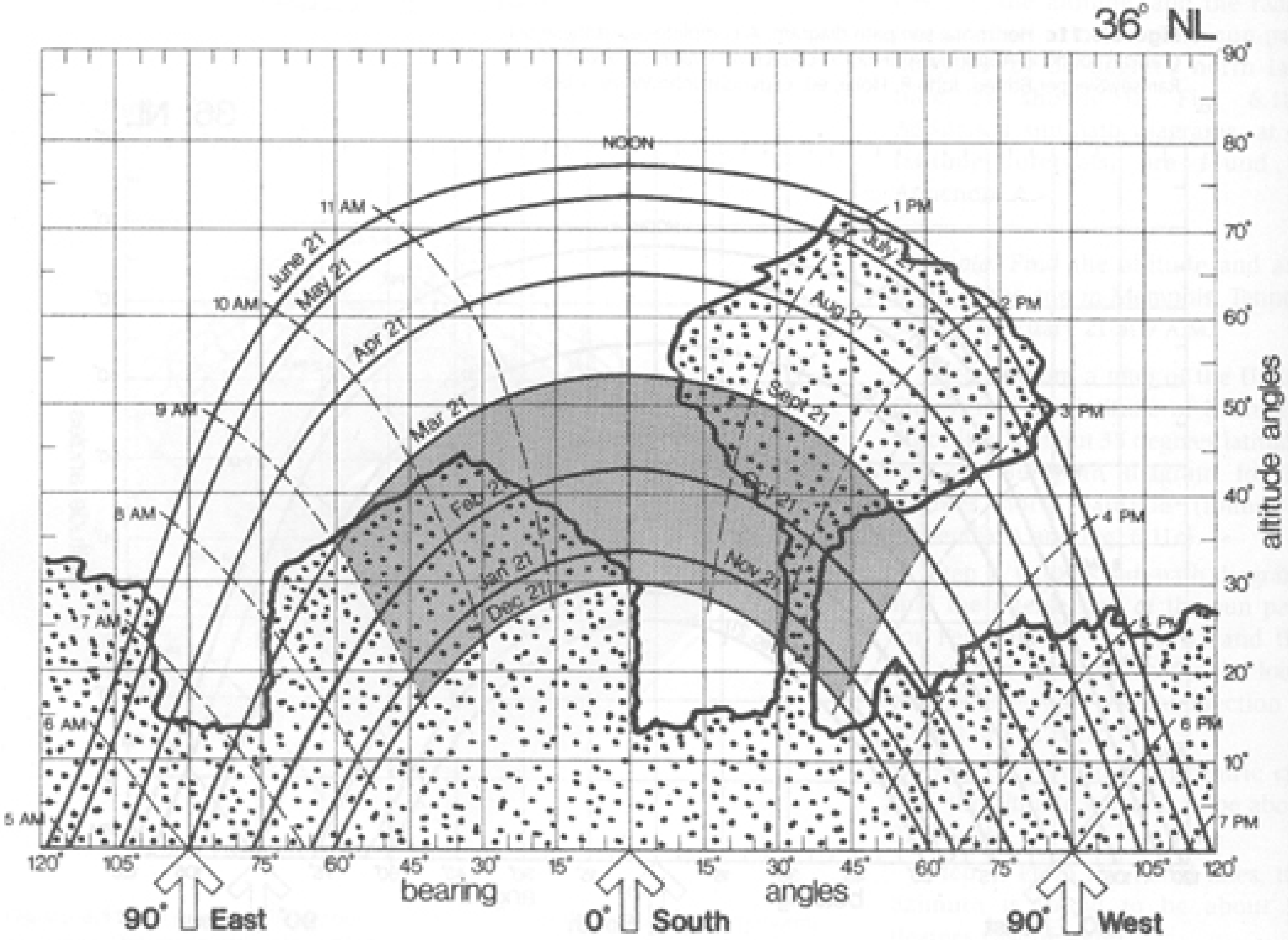


Figure 6.12b The winter solar window and silhouette of surrounding objects are shown on this vertical sun path diagram. The silhouette of a specific location was hand-drawn by means of a site-evaluator tool described in Section 6.14. (Sun path diagram from *The Passive Solar Energy Book*, copyright E. Mazria, 1979, reprinted by permission.)

HCL

Sundials

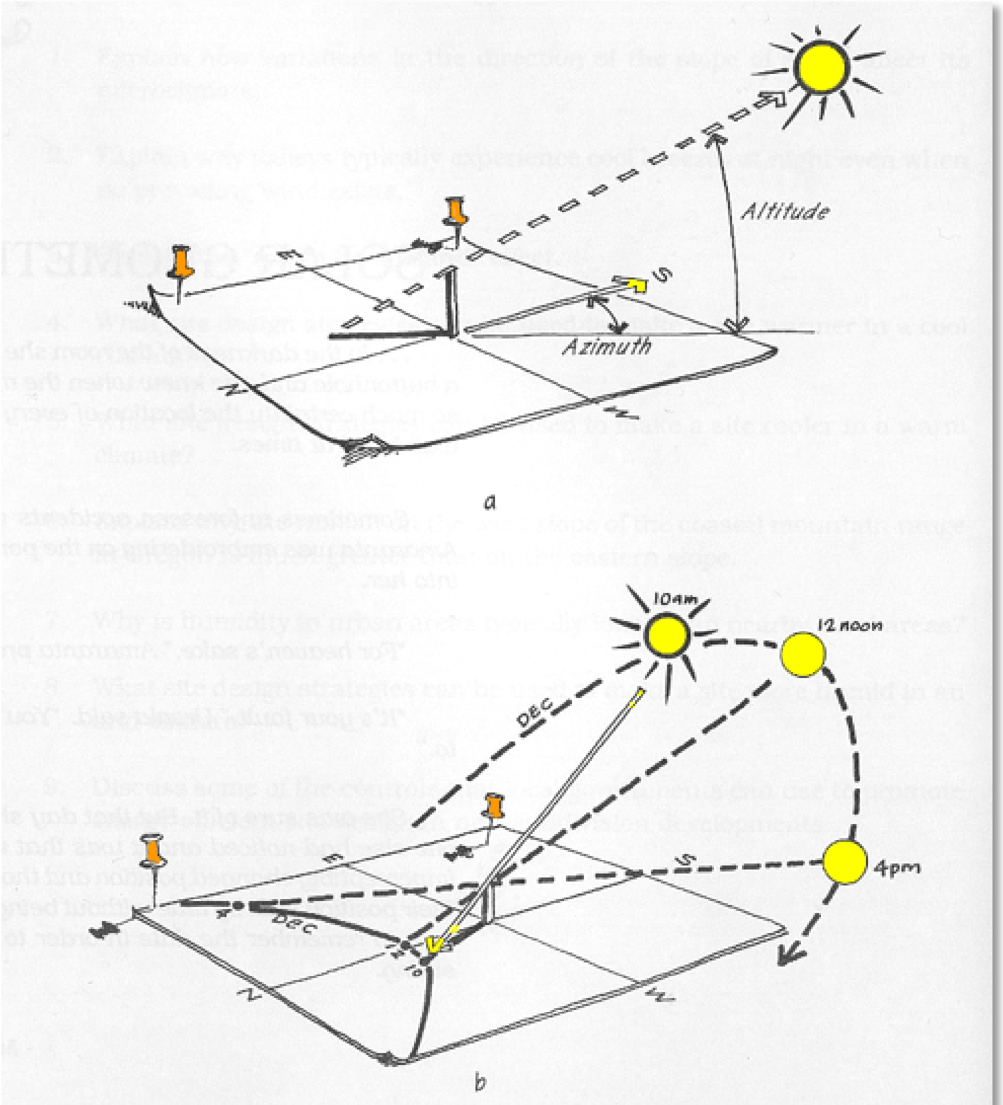


Figure 5.2: (a) Shadow location on a sundial at 2 p.m. December 21, and (b) shadow path for December 21, 40° N latitude. *(Reproduced from Moore, 1985, by permission.)*

HCL

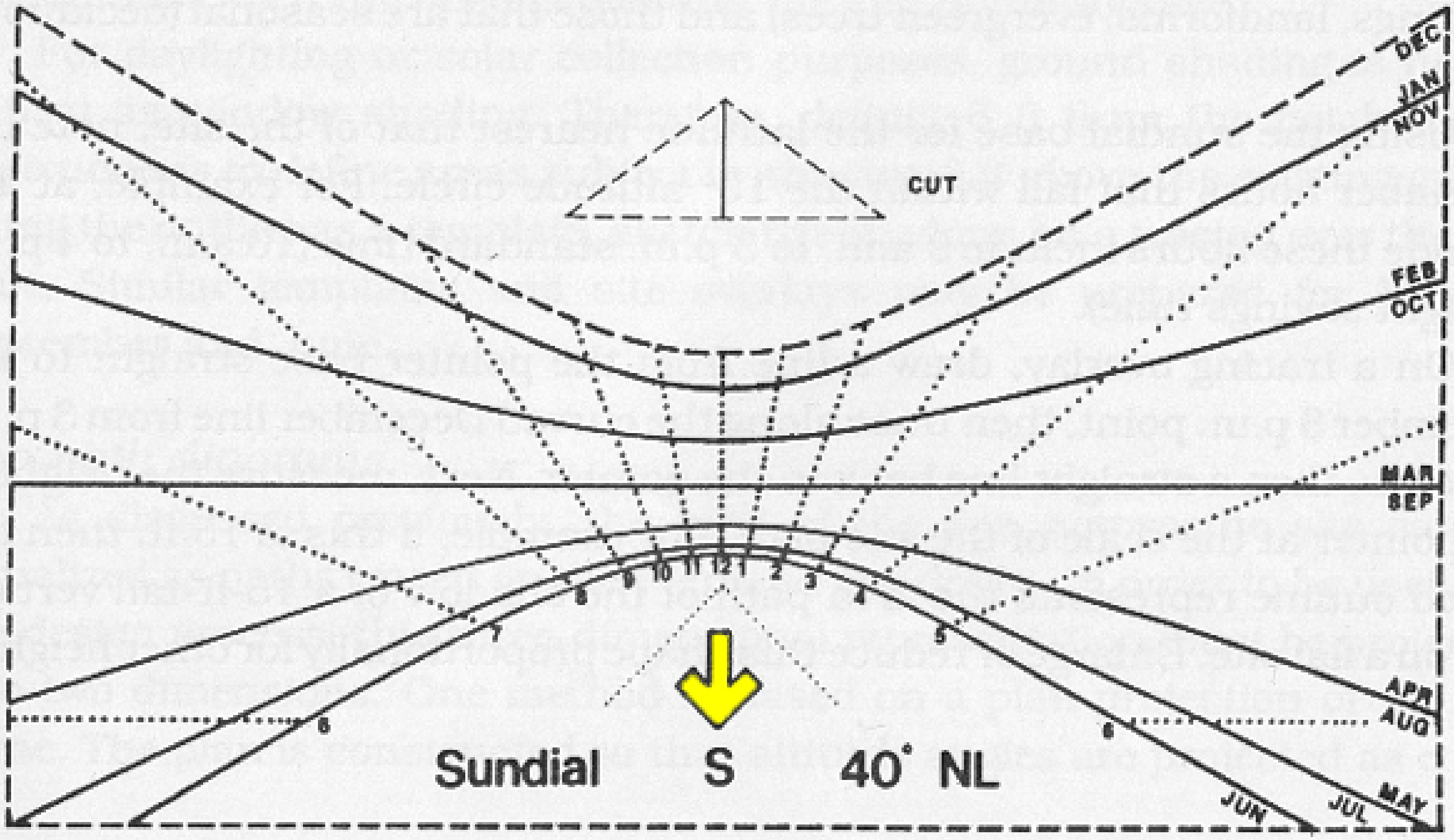


Figure 5.3: Completed sundial for 40° N. latitude. *(Reproduced from Moore, 1985, by permission.)*

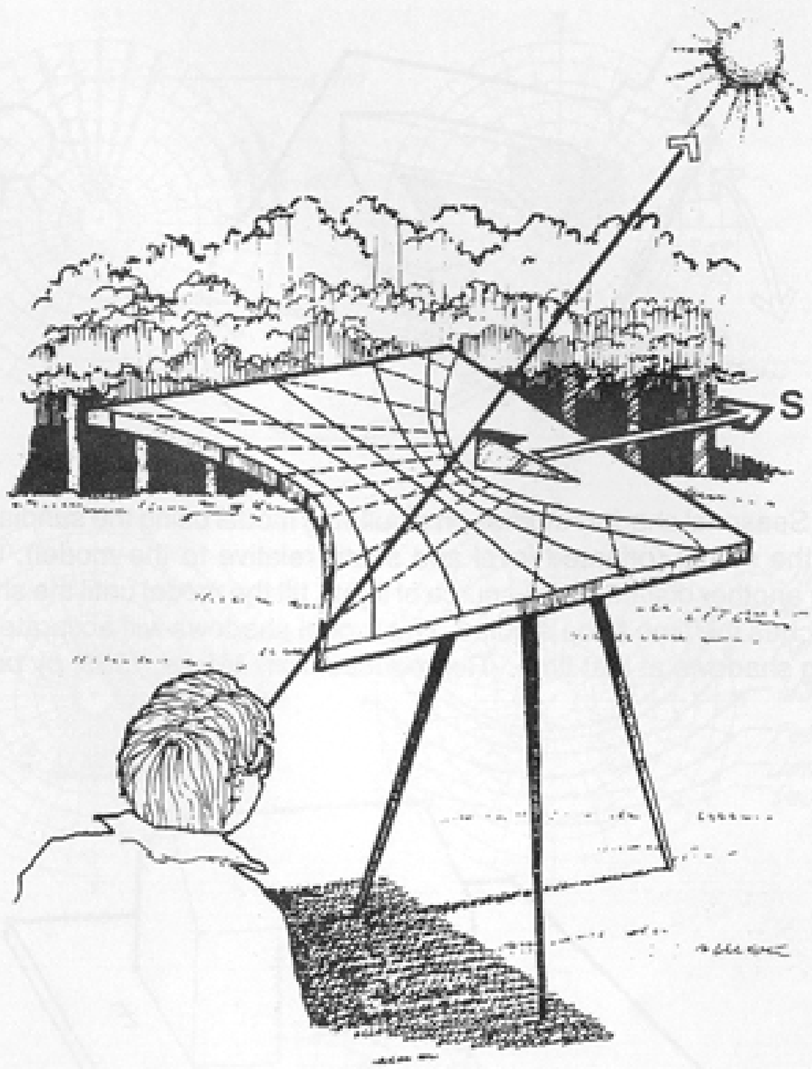
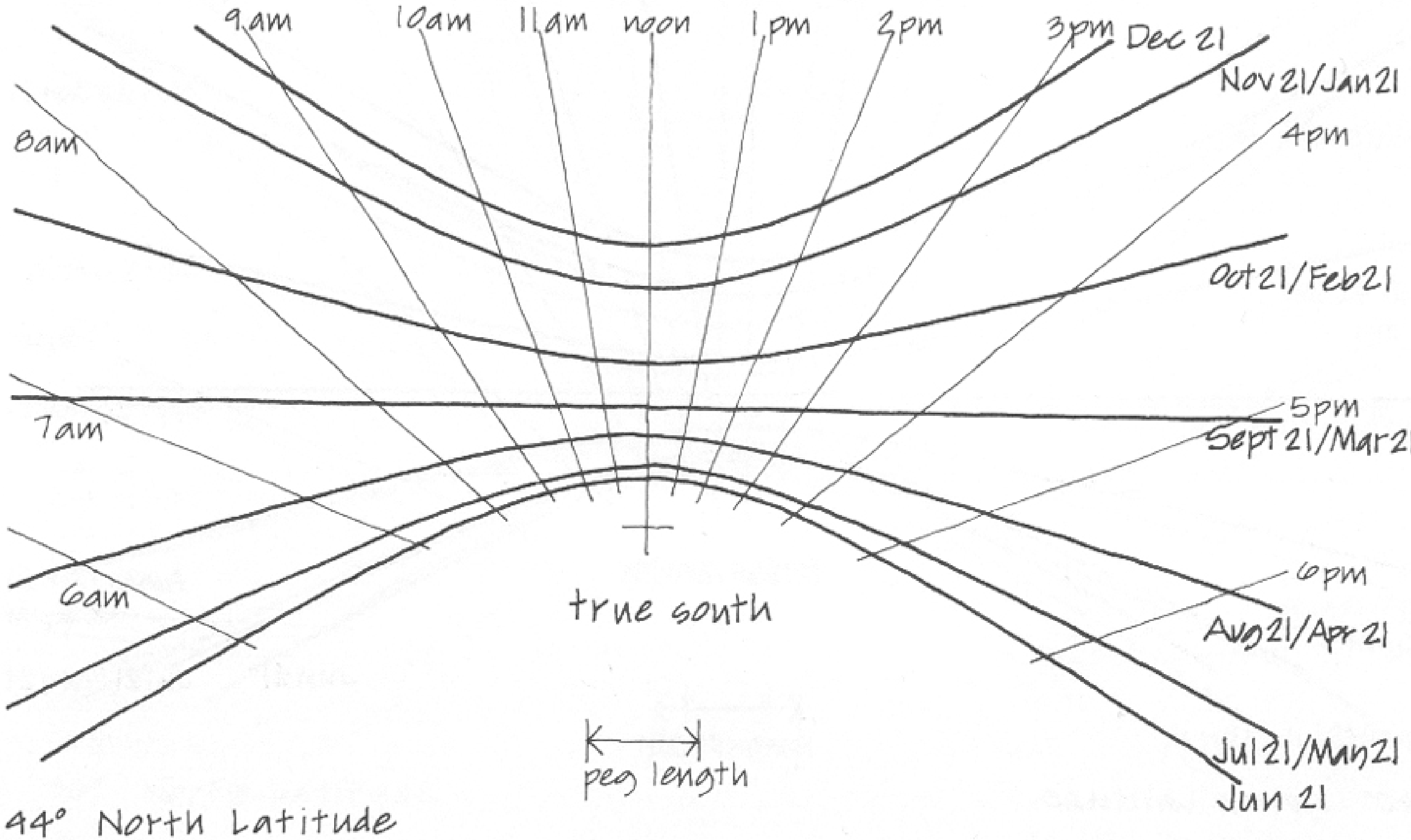


Figure 5.4: Use of sundial for preliminary obstruction survey. The sundial is level and oriented south. Sight from below from north edge, over pointer, to December sun location. *(Reproduced from Moore, 1985, by permission.)*

HCL


9am
10am
11am
noon
1pm
2pm
3pm
Dec 21
Nov21/Jan21
8am
4pm
Oct21/Feb21
5pm
7am
Sept 21/Mar21
6pm
6am
true south
Aug21/Apr21
Jul21/May21
Jun 21
peg length
44° North Latitude
SWL

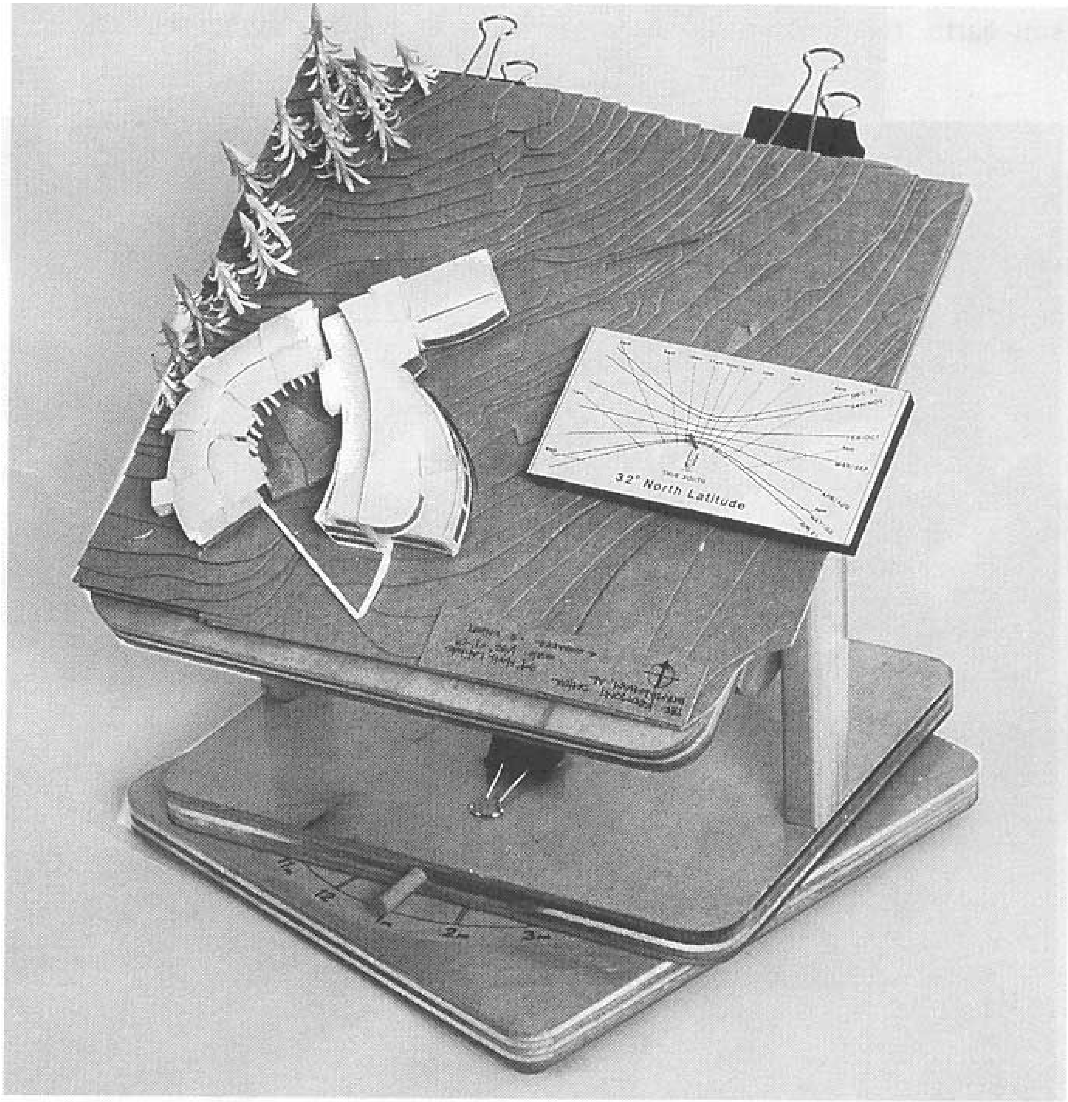


Figure 6.16 Sundials can be used to test models either under sunlight or an artificial light source.

HCL

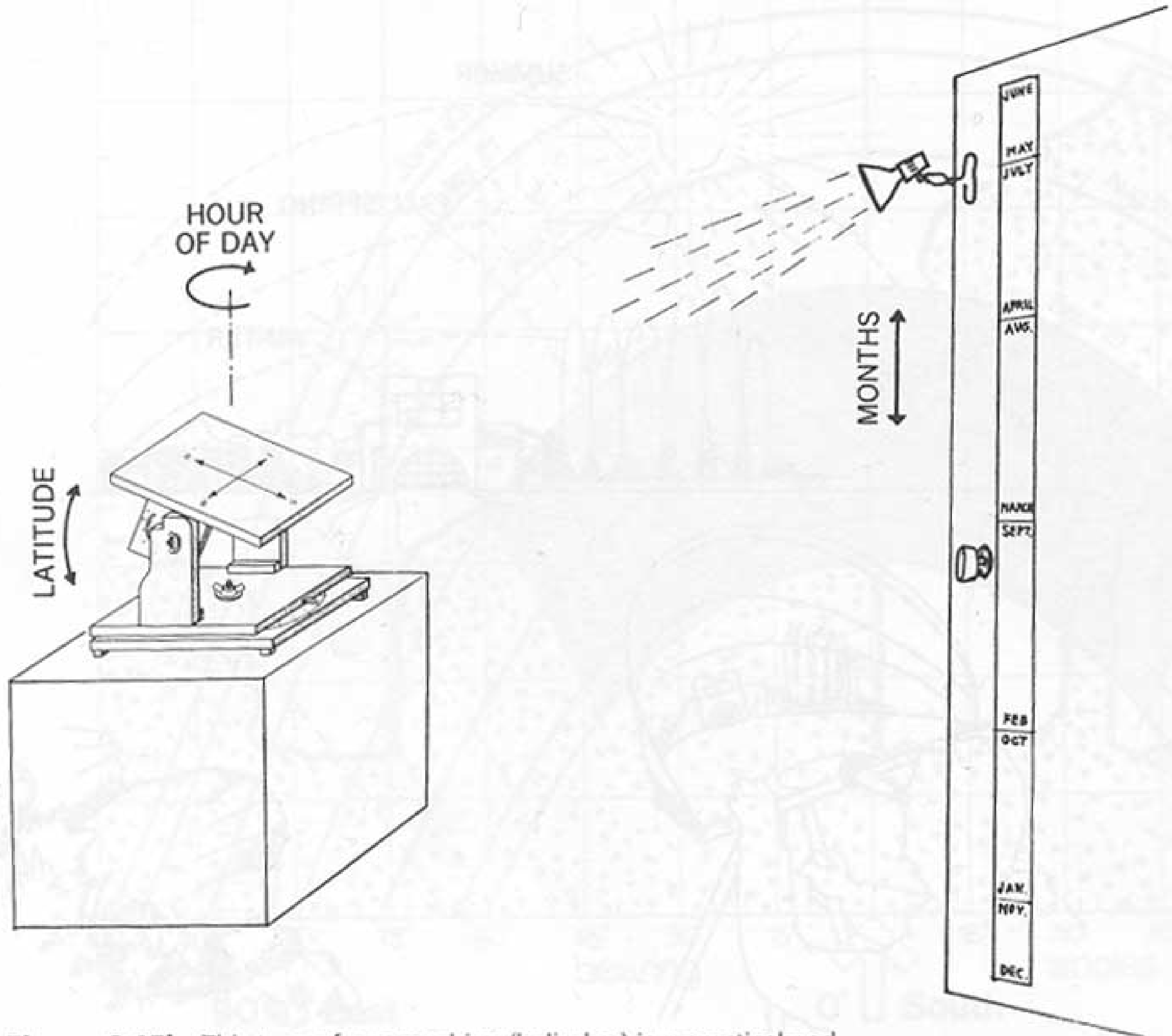
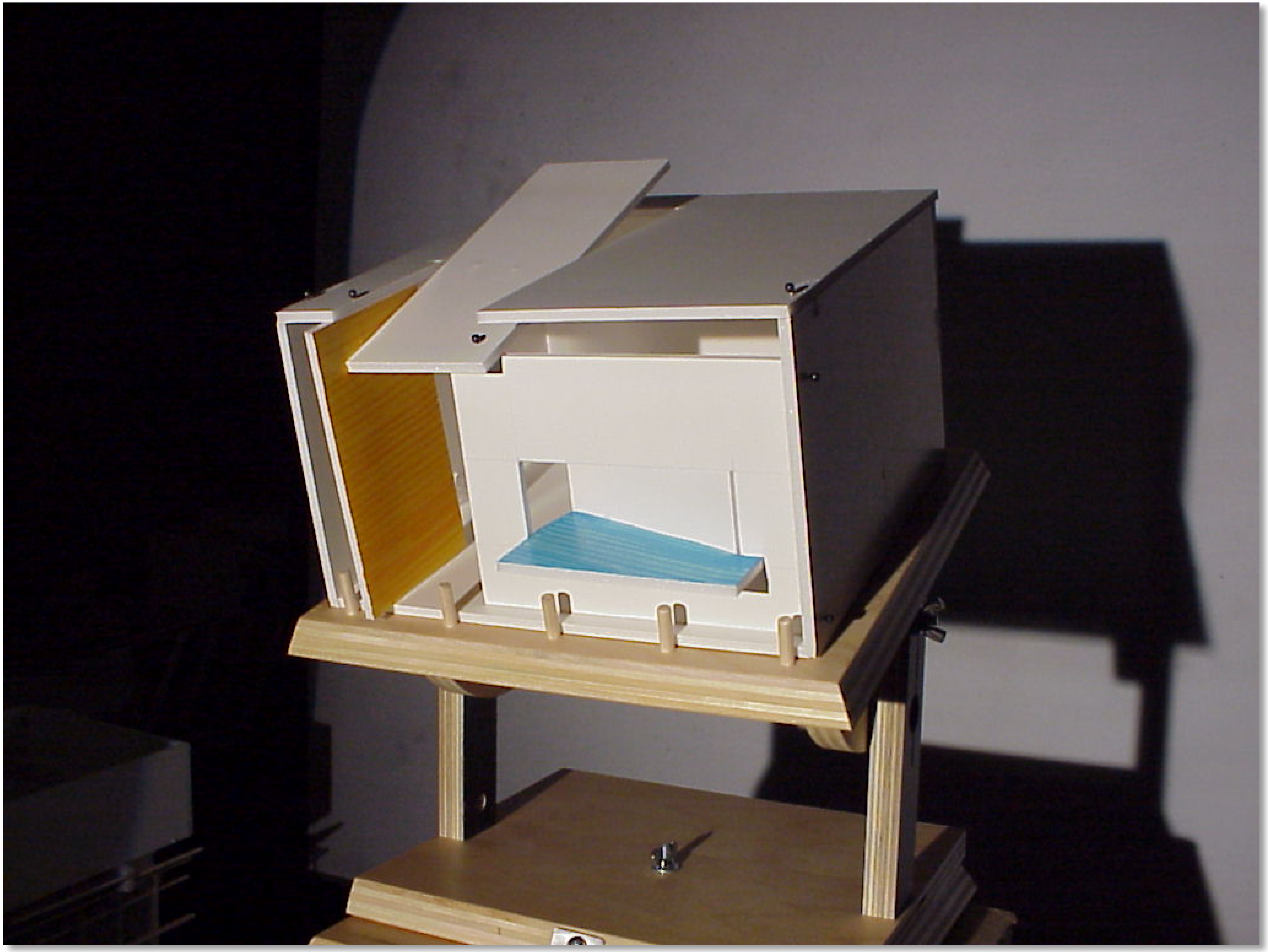
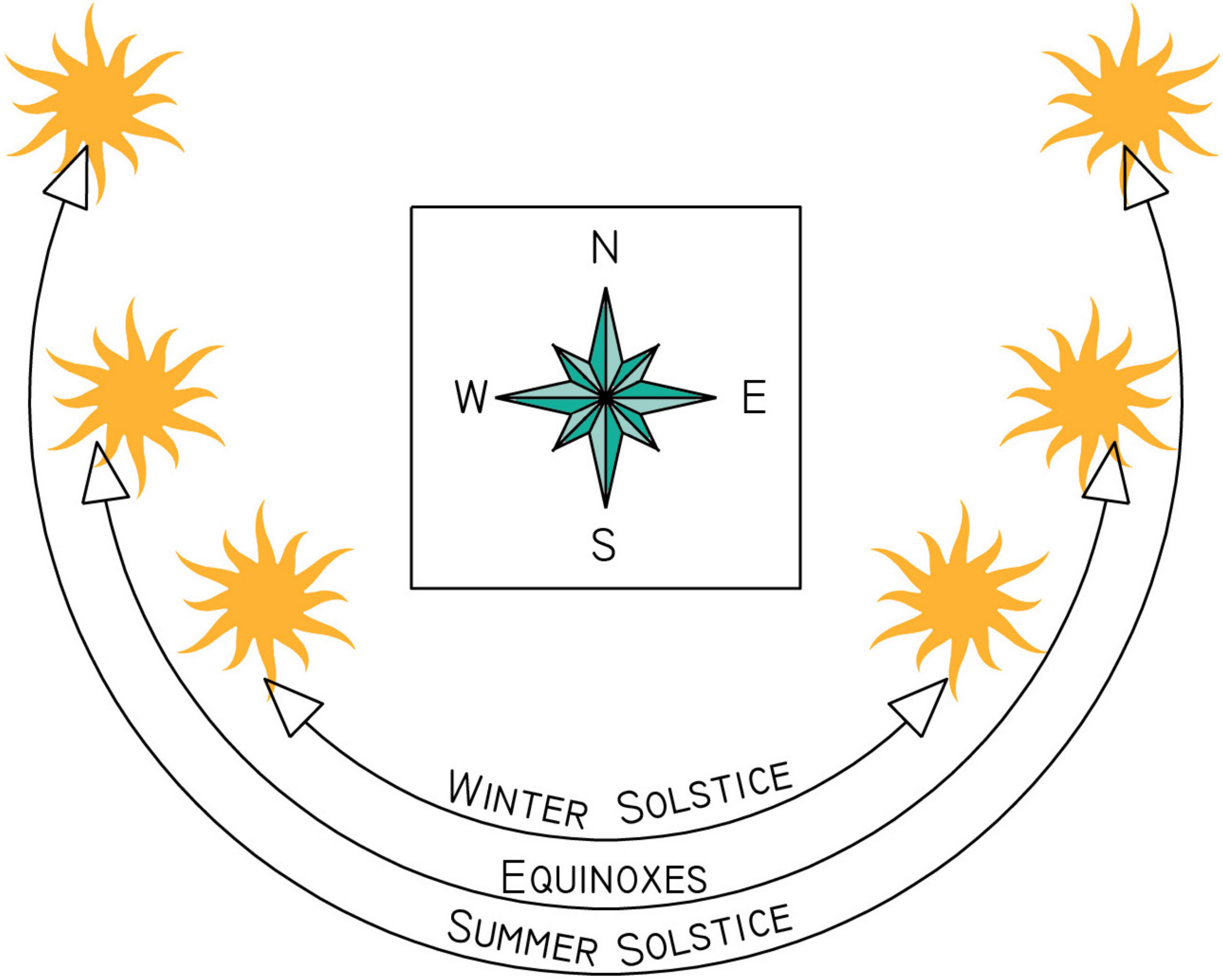


Figure 6.15b This type of sun machine (heliodon) is a practical and appropriate tool for every design studio.

HCL



Solar Azimuth Range Throughout the Year



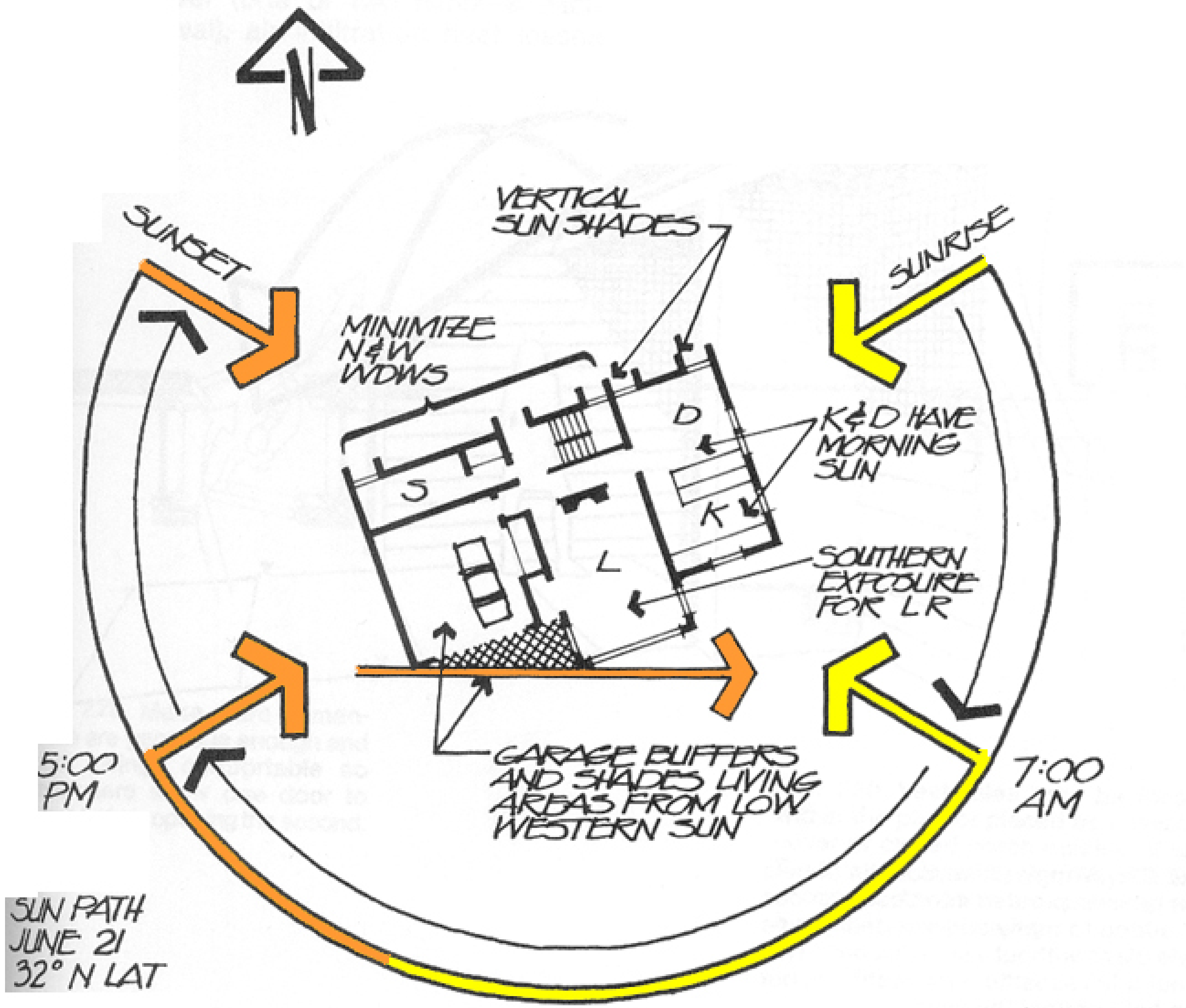


FIG. 21a

We begin to make key layout decisions based upon exposure to sun for heat and light.

CBD

We begin to make key layout decisions based upon exposure to sun for heat and light.

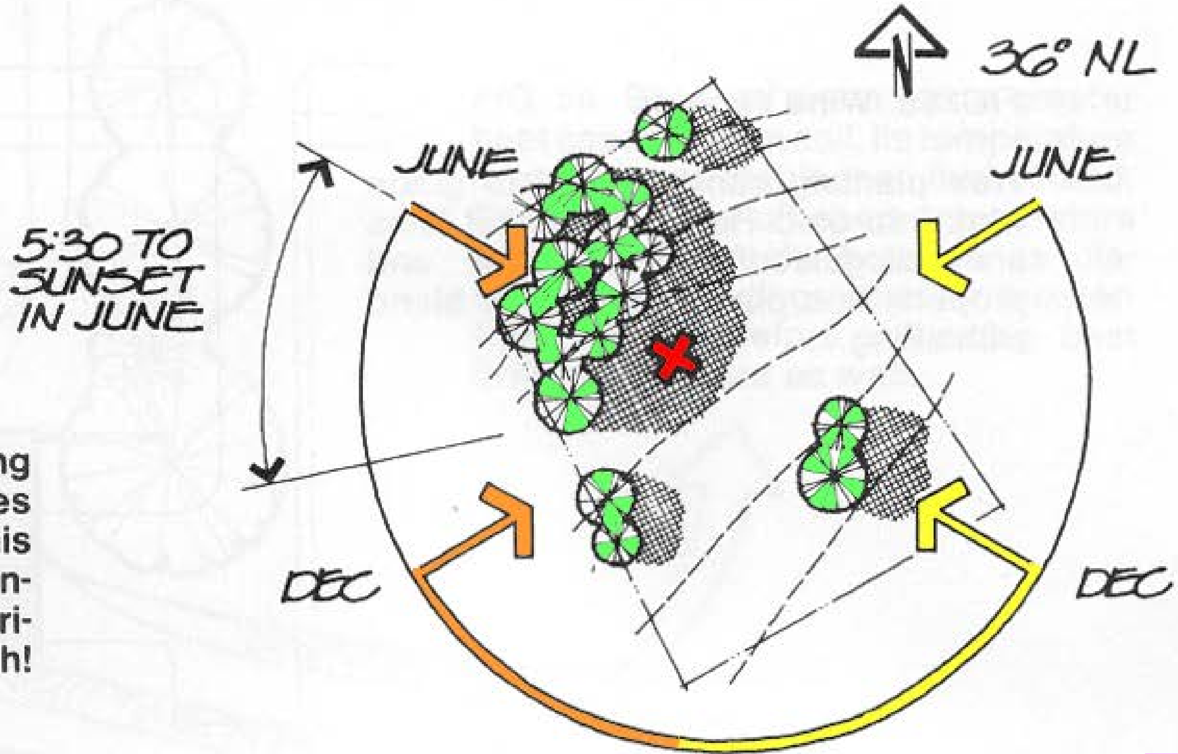
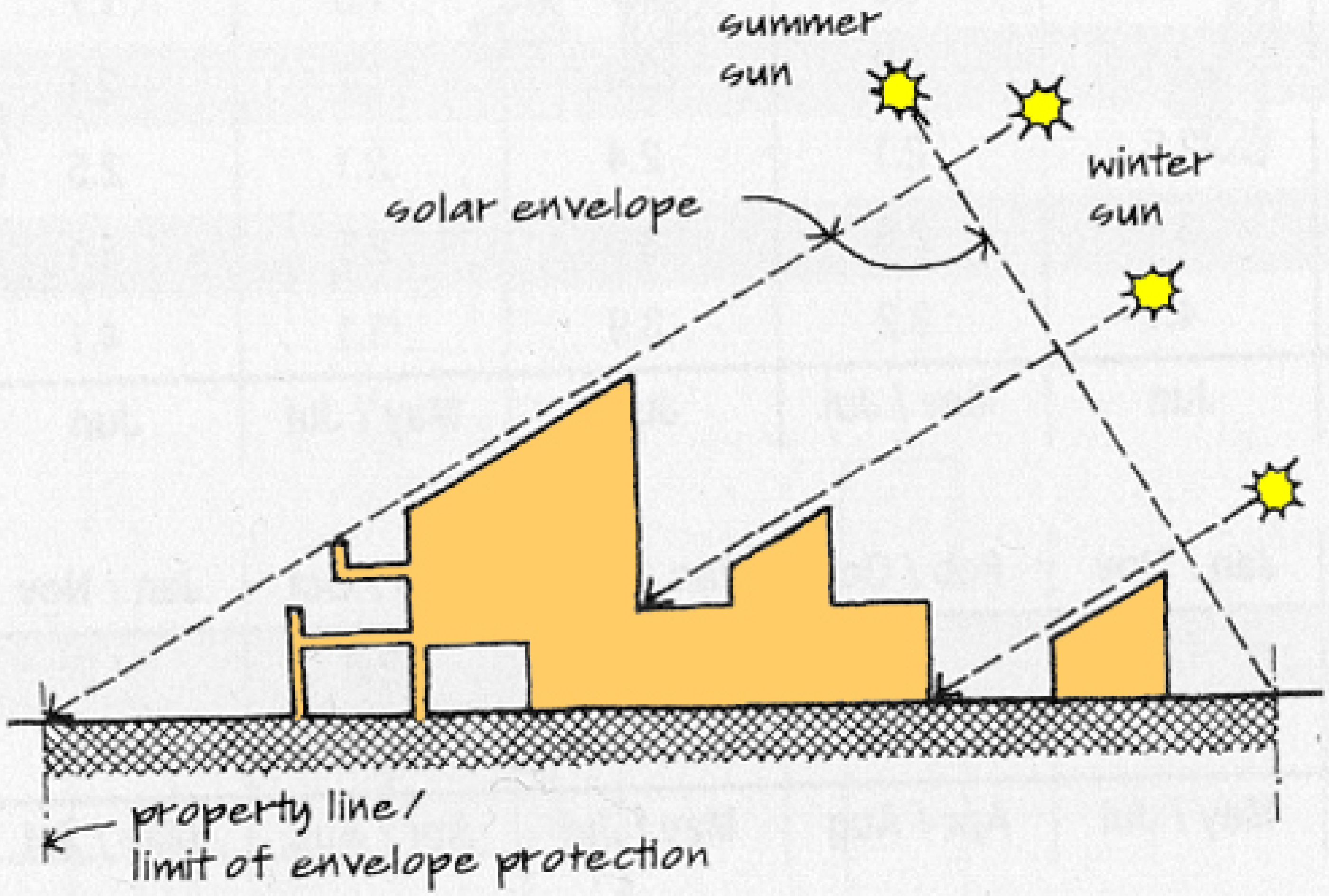


FIG. 4a "X" marks the spot for existing on-site sun protection. Look for sites shrouded by trees on west side. In this example, trees are on upslope, enhancing their shading ability. Don't sacrifice winter southern exposure, though!

CBD



Solar Collection Within the Solar Envelope

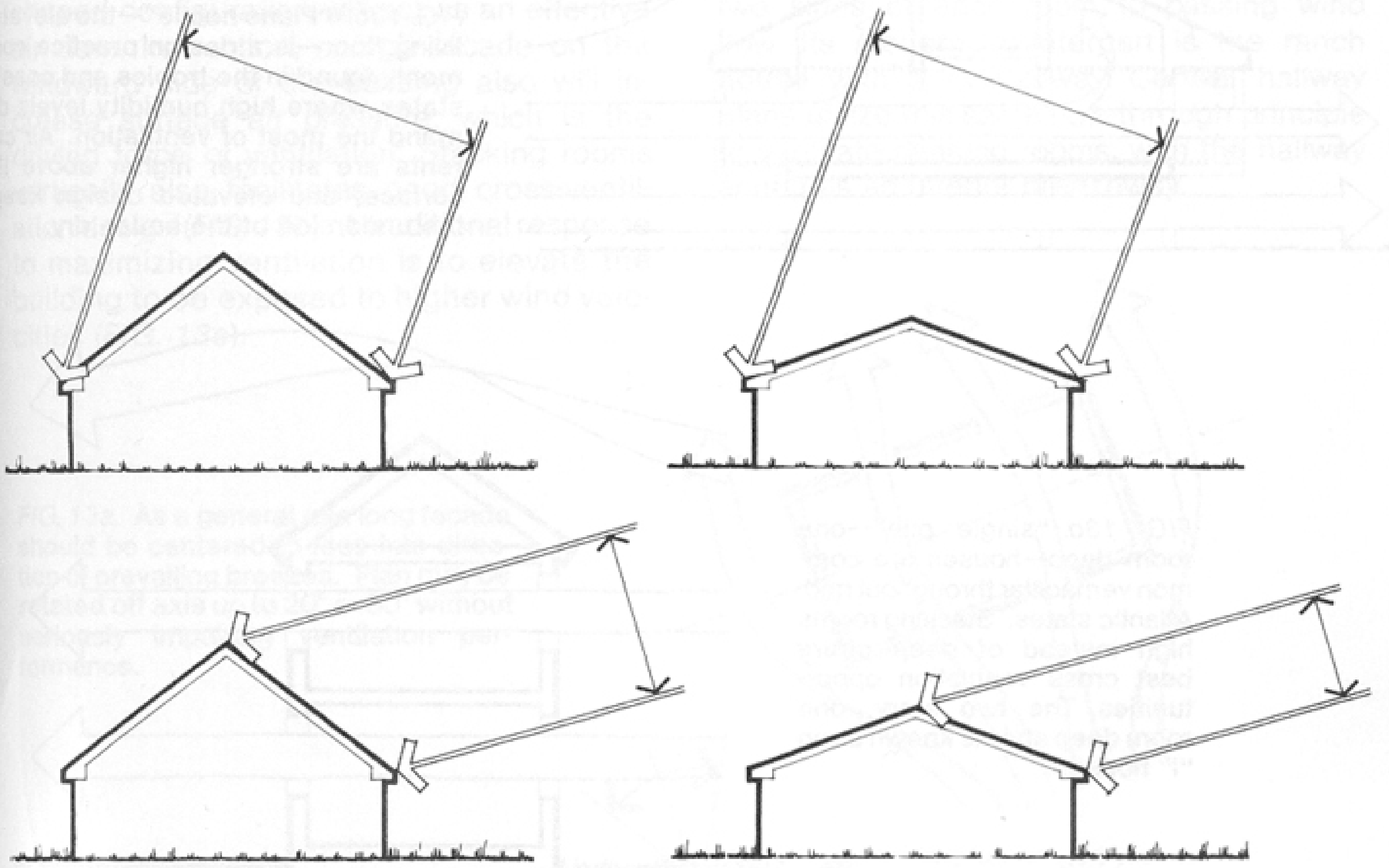


FIG. 12c. **Roof shape has little effect on mid-day gain when sun is high.**

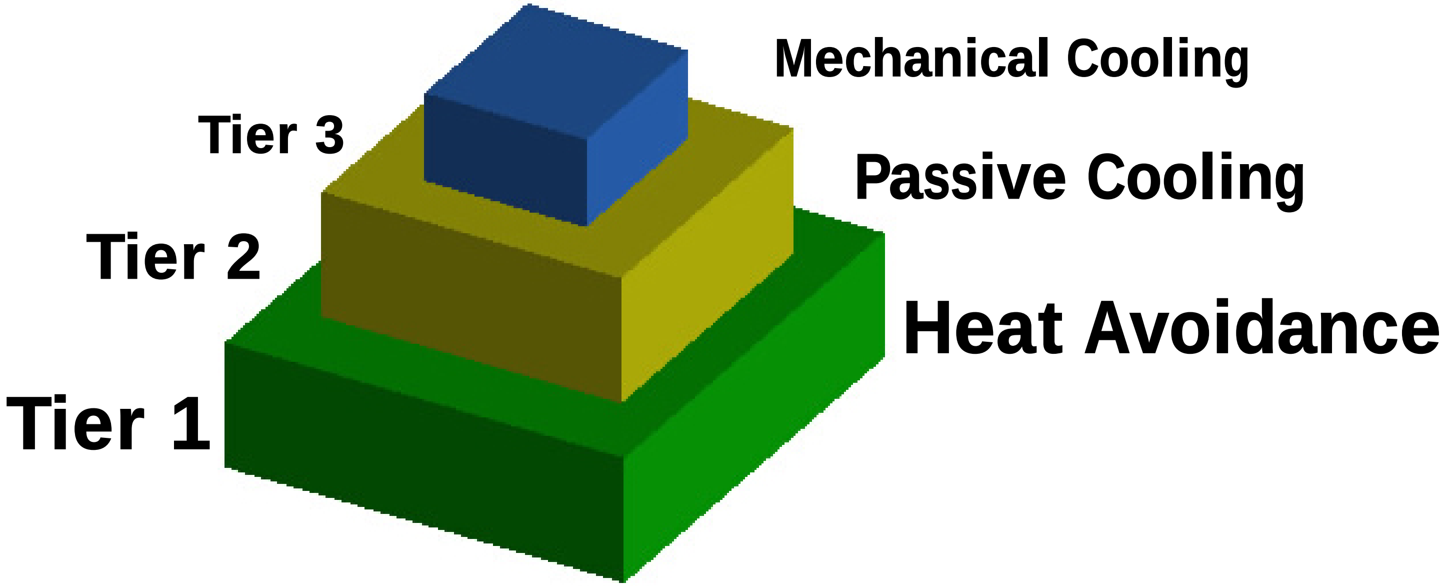
HCL

Arch 125: Intro to Environmental Design

SOLAR SHADING

Shading is a key strategy of achieving thermal comfort in the summer months.

The tiered approach to reducing carbon for COOLING:



Maximize the amount of energy required for mechanical cooling that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

HCL

Two main methods of preventing overheating:

1. Prevent the sun from hitting the glass: done using roof overhangs, special shading devices or vegetation.

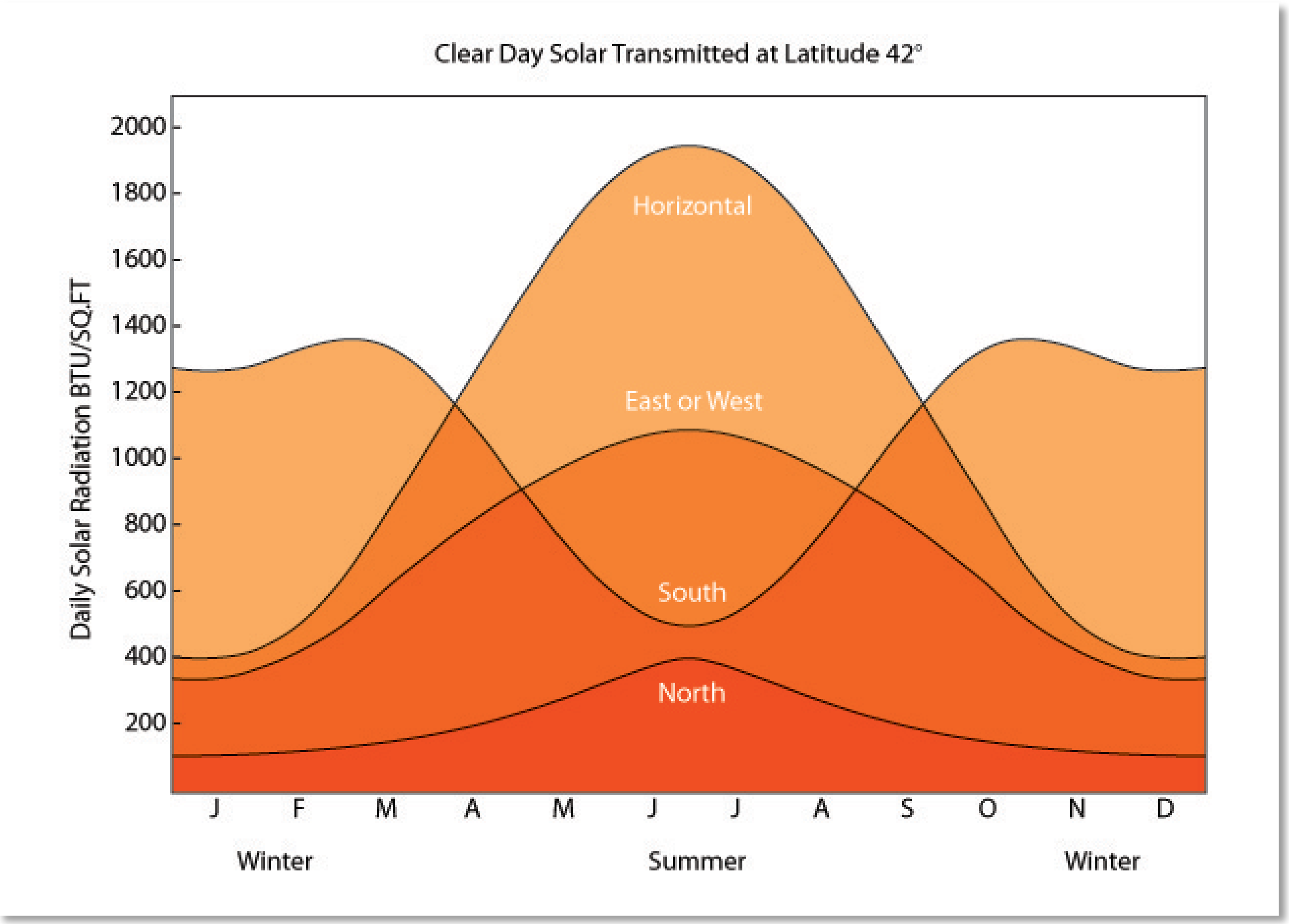
OR

2. Use special glazing -- "spectrally selective" -- that filters the harmful rays out of the sunlight striking the glass.

Which orientations get how much??

-A horizontal window (skylight) receives 4 to 5 times more solar radiation than south window on June 21.

-East and West glazing collects almost 3 times the solar radiation of south window.



The Function of Glazing

The larger the angle of incidence (steepness of the sun angle), the less transmittance.

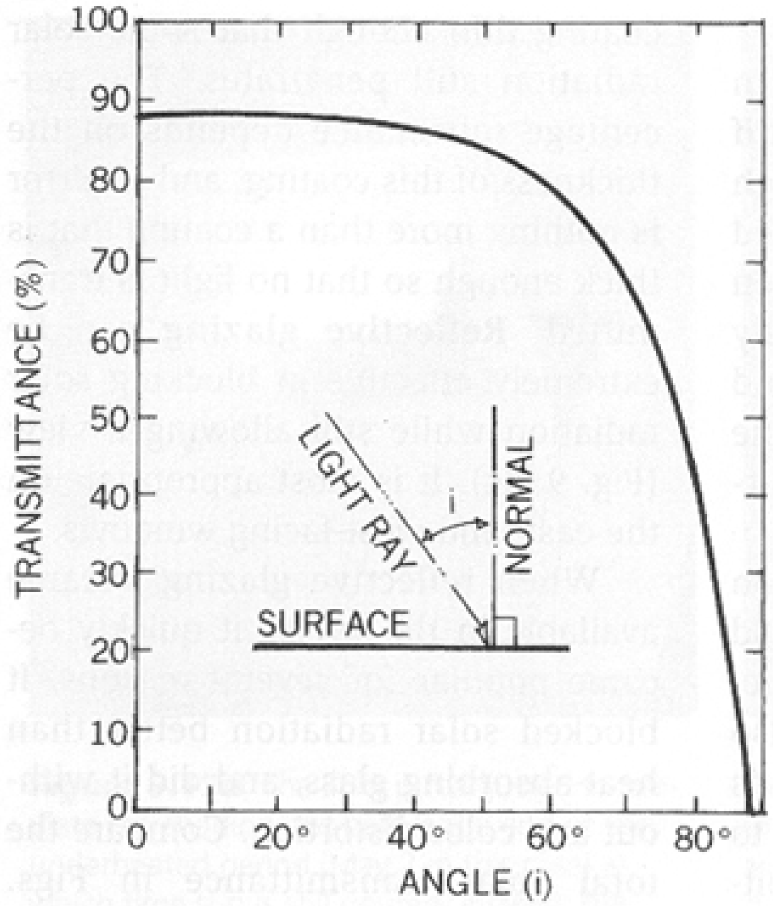
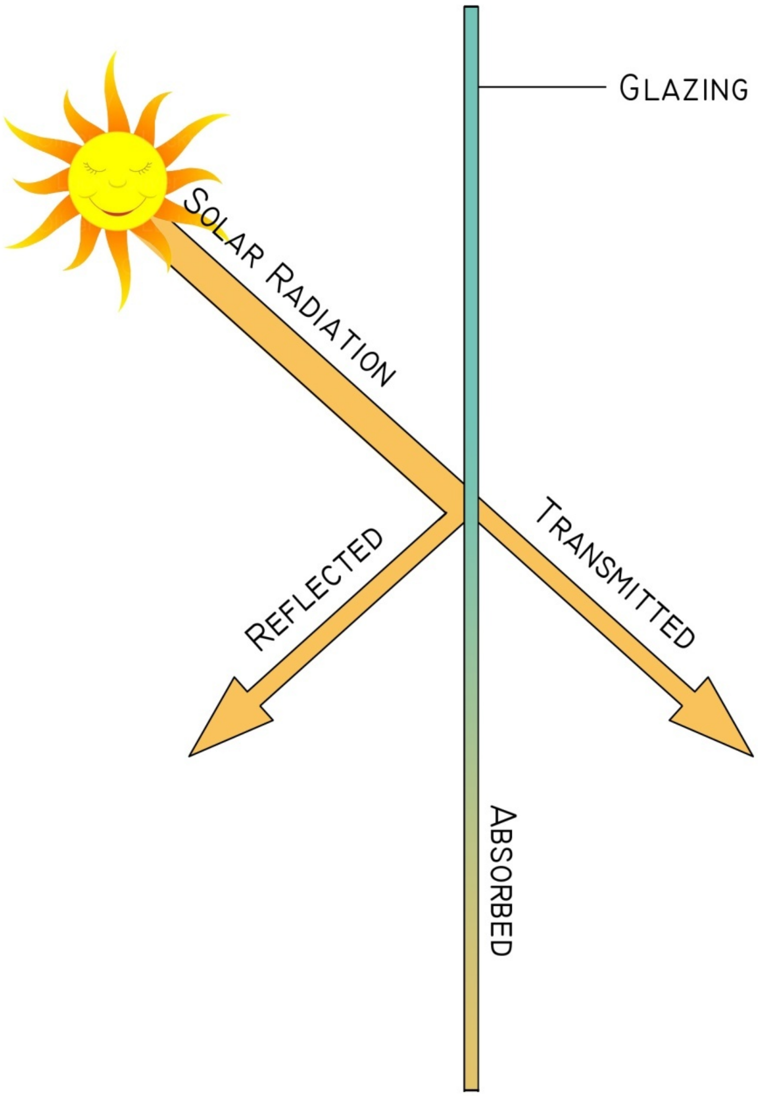
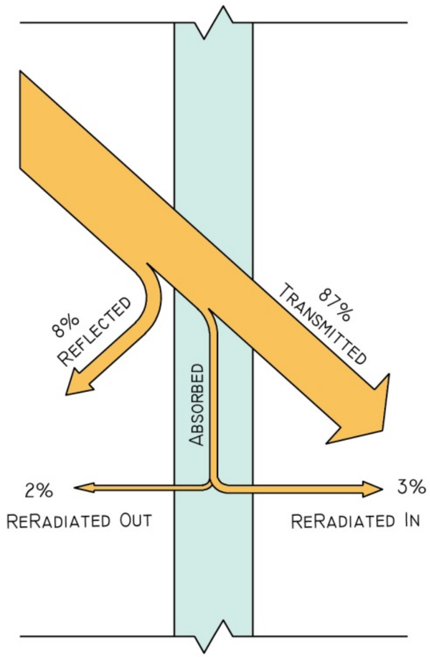


Figure 9.18d The transmittance of solar radiation through glazing is a function of the angle of incidence, which is always measured from the normal to the surface.

HCL


Glazing
Solar Radiation
Reflected
Transmitted
Absorbed

Clear Glass

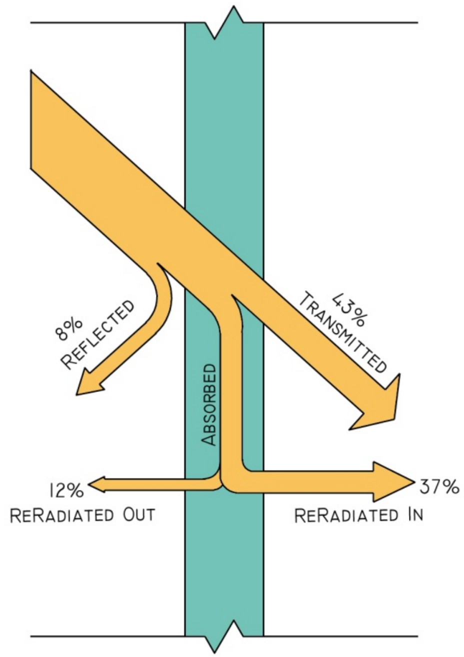


Most of the incident solar radiation is:

Transmitted

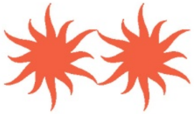
Heat Gain: 

Heat Absorbing Glass

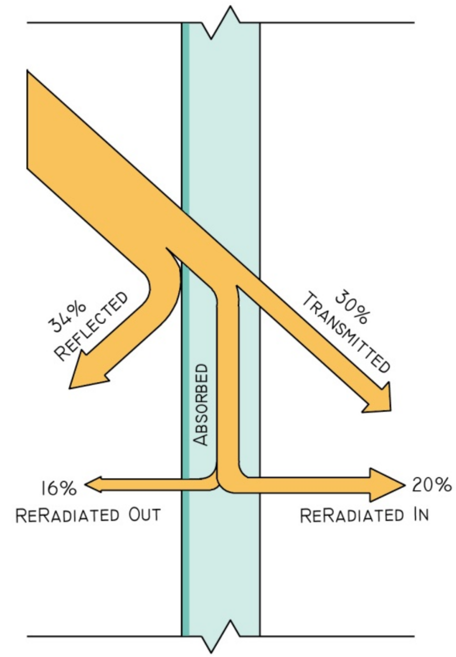


Most of the incident solar radiation is:

Transmitted + Reradiated In

Heat Gain: 

Reflective Glass



Most of the incident solar radiation is:

Reflected

Heat Gain: 

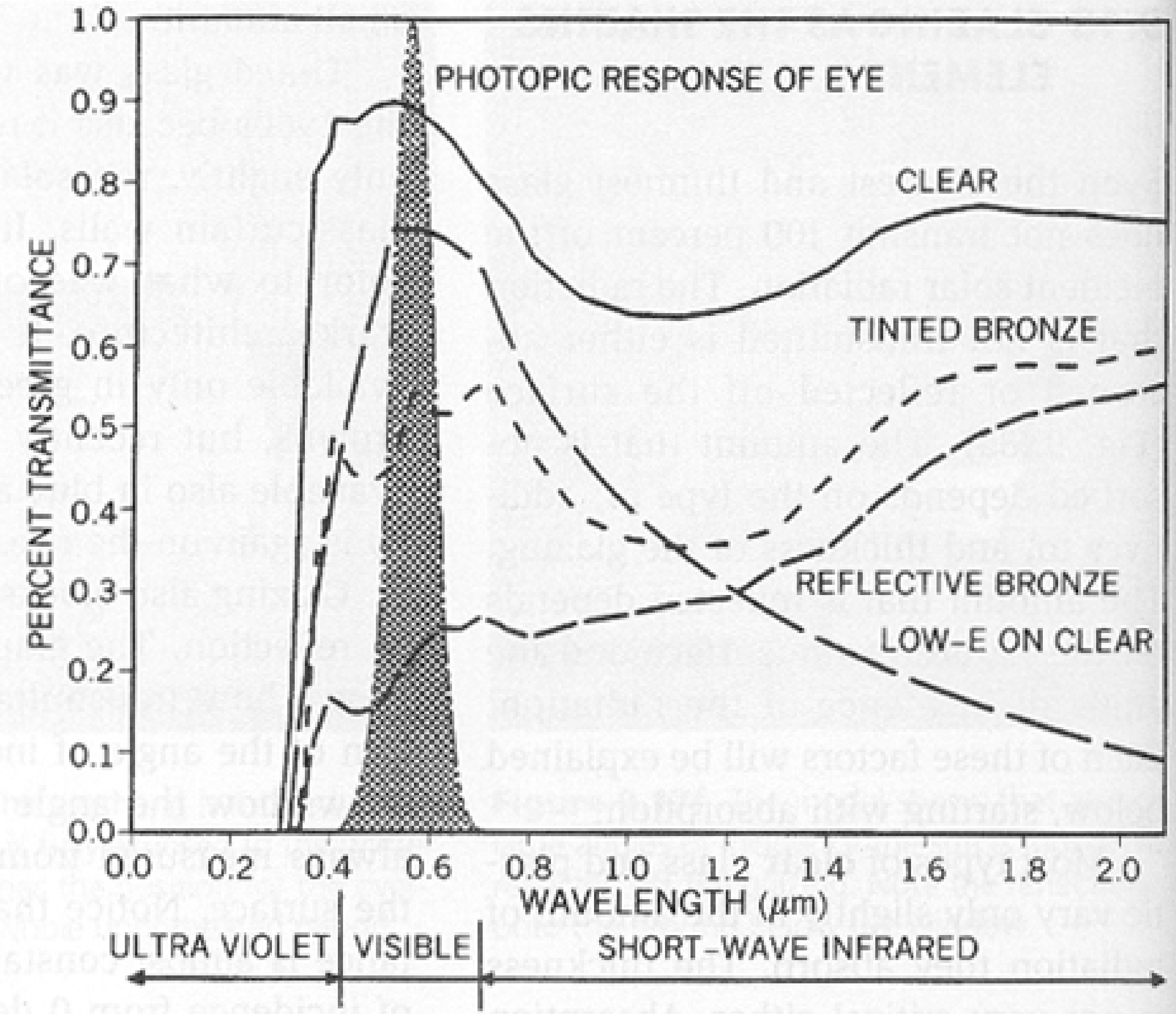
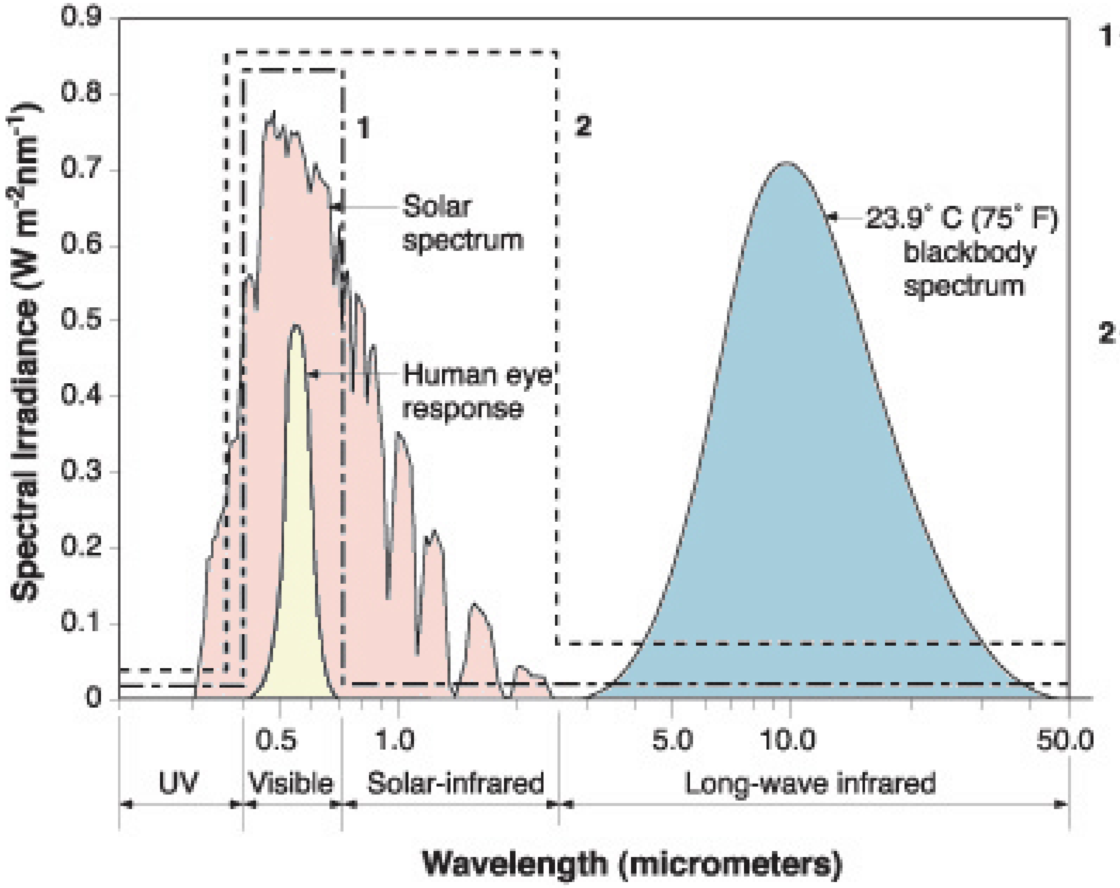


Figure 9.18f Spectally selective low-e glazing transmits cooler daylight because it reflects the short-wave infrared much more than the visible radiation. (From "Effects of Low Emissivity Glazings on Energy Use Patterns," *ASHRAE Transactions*, Vol. 93, Pt. I 1989.)

Green on the Grand in Kitchener uses spectrally selective glazing and no shading devices to control heat gain.

HCL



1 — - — Idealized transmittance of a glazing with a low-E coating designed for low solar heat gain. Visible light is transmitted and solar-infrared radiation is reflected. Long-wave infrared radiation is reflected back into the interior. This approach is suitable for commercial buildings in almost all climates.

2 - - - - Idealized transmittance of a glazing with a low-E coating designed for high solar heat gain. Visible light and solar-infrared radiation are transmitted. Long-wave infrared radiation is reflected back into the interior. This approach is more commonly used for residential windows in cold climates.

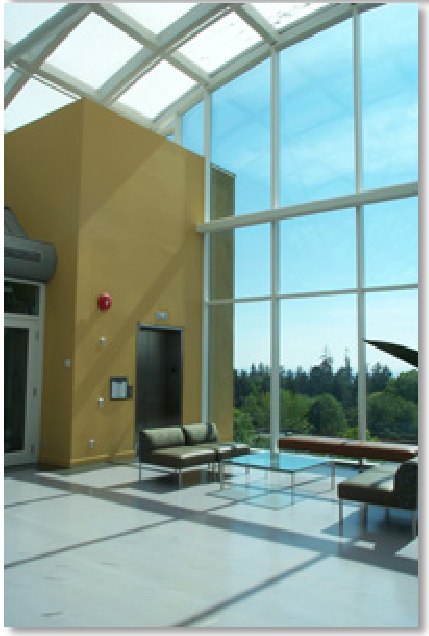
Note: As shown by the solar spectrum in the figure, sunlight is composed of electromagnetic radiation of many wavelengths, ranging from short-wave invisible ultraviolet to the visible spectrum to the longer, invisible solar-infrared waves.

Figure 2-3. Ideal spectral transmittance for glazings in different climates (Source: McCluney, 1996)

TABLE 9.20 SHADING COEFFICIENTS (SC) AND SOLAR HEAT GAIN COEFFICIENTS (SHGC) FOR VARIOUS SHADING DEVICES

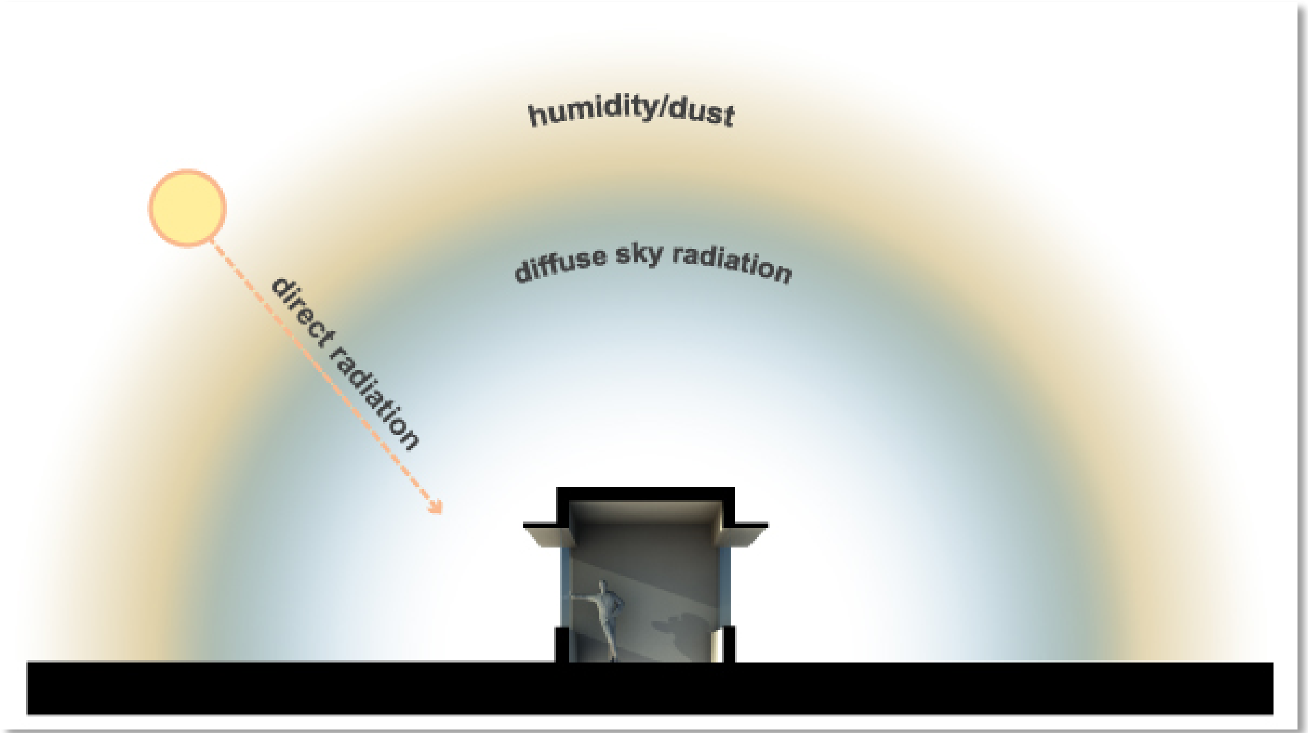
Device	SC	SHGC
Single glazing		
Clear glass, 1/8-inch thick	1.0	0.86
Clear glass, _-inch thick	0.94	0.81
Heat absorbing or tinted	0.6–0.8	0.5–0.7
Reflective	0.2–0.5	0.2–0.4
Double glazing		
Clear	0.84	0.73
Bronze	0.5–0.7	0.4–0.6
Low-e clear	0.6–0.8	0.5–0.7
Spectrally selective	0.4–0.5	0.3–0.4
Triple-clear	0.7–0.8	0.6–0.7
Glass Block	0.1–0.7	
Interior shading		
Venetian blinds	0.4–0.7	
Roller shades	0.2–0.6	
Curtains	0.4–0.8	
External shading		
Eggcrate	0.1–0.3	
Horizontal overhang	0.1–0.6	
Vertical fins	0.1–0.6	
Trees	0.2–0.6	

NOTES:
1. The smaller the number, the less solar radiation enters through a window. A value of zero indicates that the window allows no solar radiation to enter either directly or reradiated after being absorbed.
2. Ranges are given either because of the large variety of glazing types available (e.g., slightly or heavily tinted) or because of the varying geometry due to differences in orientation, sun angle, size and type of shading device, and variations in window size.
3. Source: ASHRAE Fundamentals Handbook 1997, Egan, 1975.

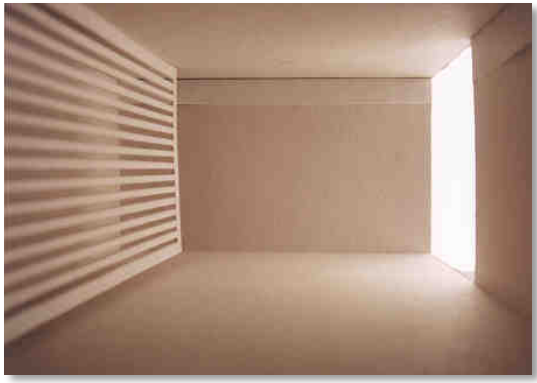


HCL

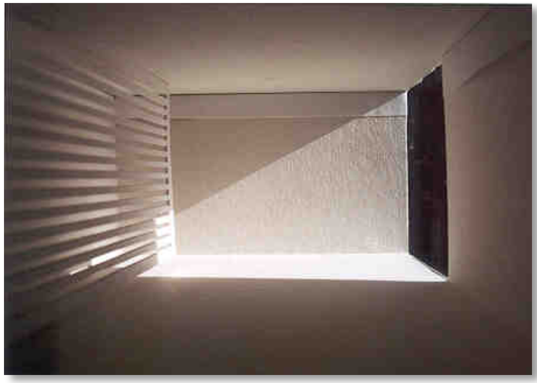
The Function of the Atmosphere



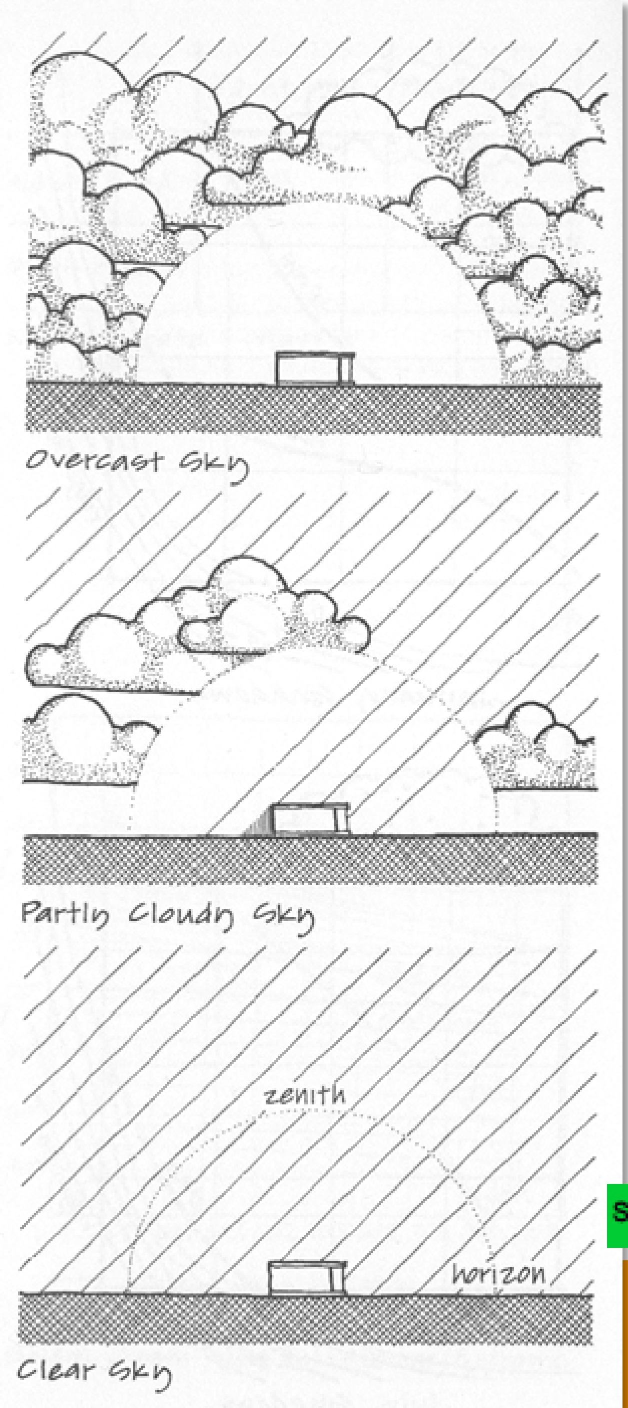
The precise condition of the sky is taken into account when determining the amount of solar radiation that is received by a building. *The clearer the sky, the more energy received.*



diffuse



direct



SWL

When it is cloudy the rays are diffused and even less radiation reaches the earth's surface. Shadows are less severe and light is more even.

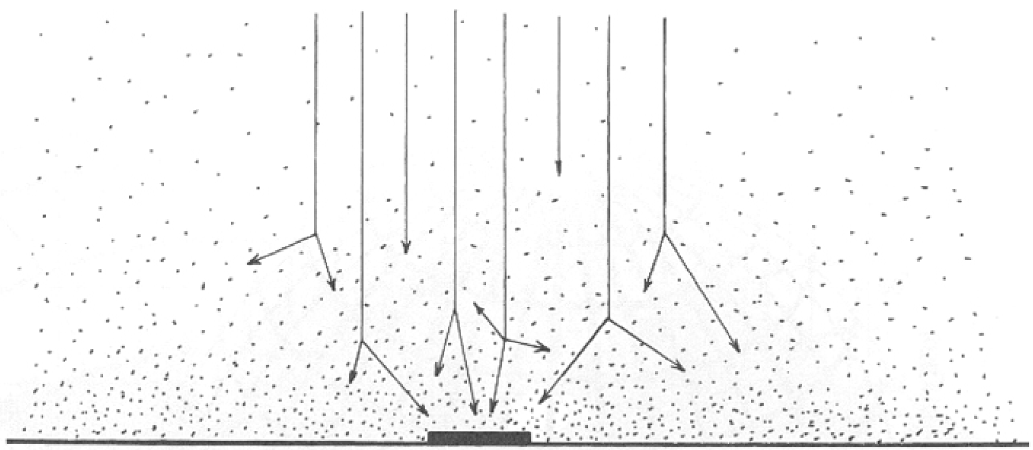


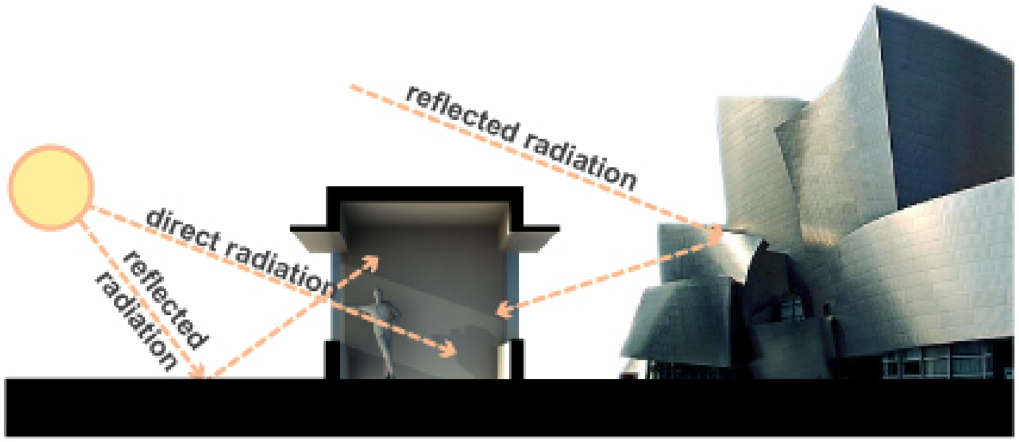
Figure 6.9b Diffuse radiation.

HCL

So even within the same space, the **microclimate** will change due to solar conditions from one day to the next.

The diffuse light on the cloudy day more evenly illuminates all faces of the building, leaving no faces in dark shadow.

The Disney Concert Hall in Los Angeles required remediation to its shiny skin as the curves were creating hot points in the adjacent streets that were dangerous to cars and pedestrians.



Reflective glazing

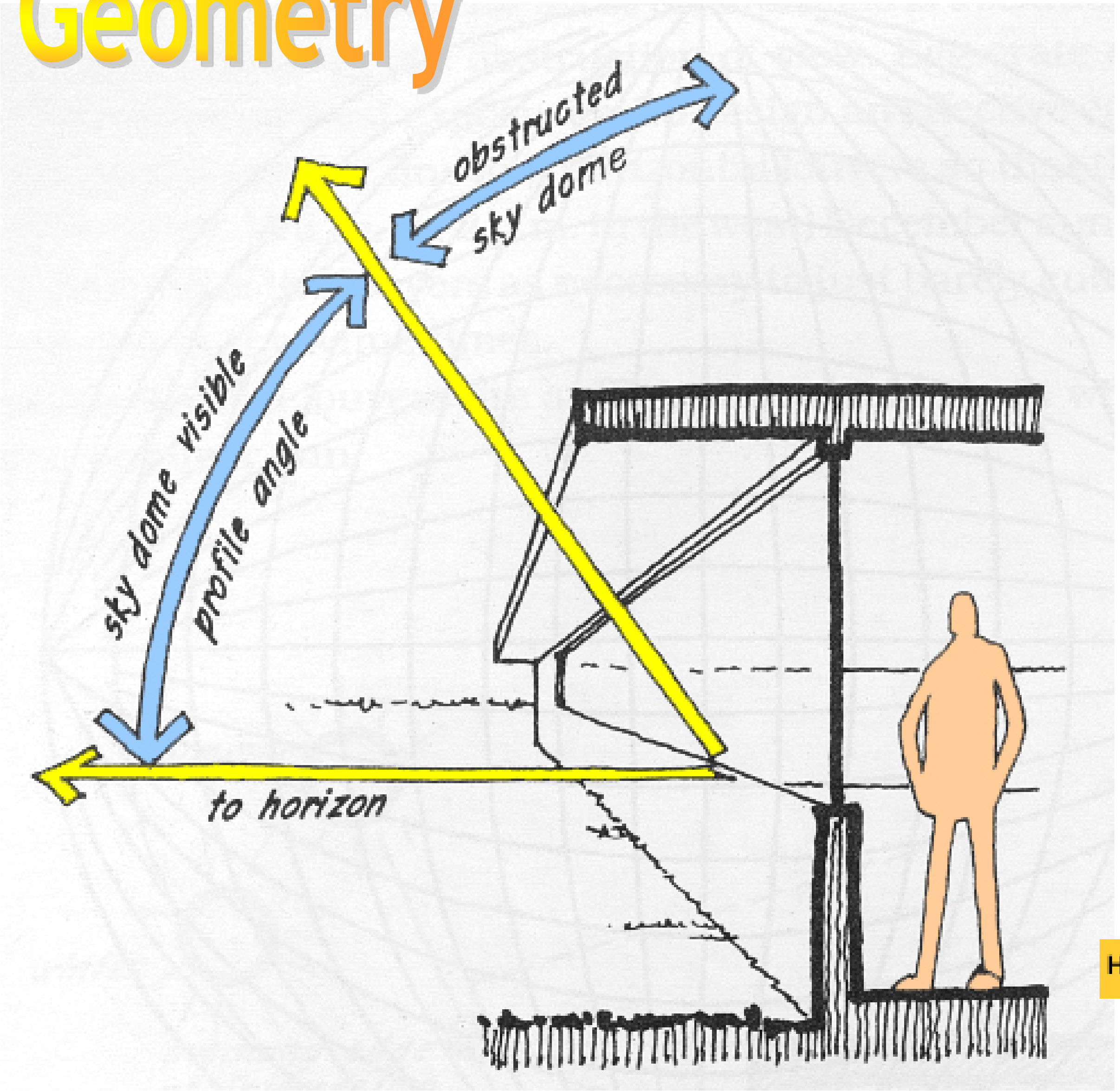
Rafael Vignoly's infamous "Walkie Scorchie" skyscraper in London, England

http://www.theguardian.com/uk-news/video/2013/sep/03/london-walkie-talkie-skyscraper-video

Image: Evelyn Hoffman

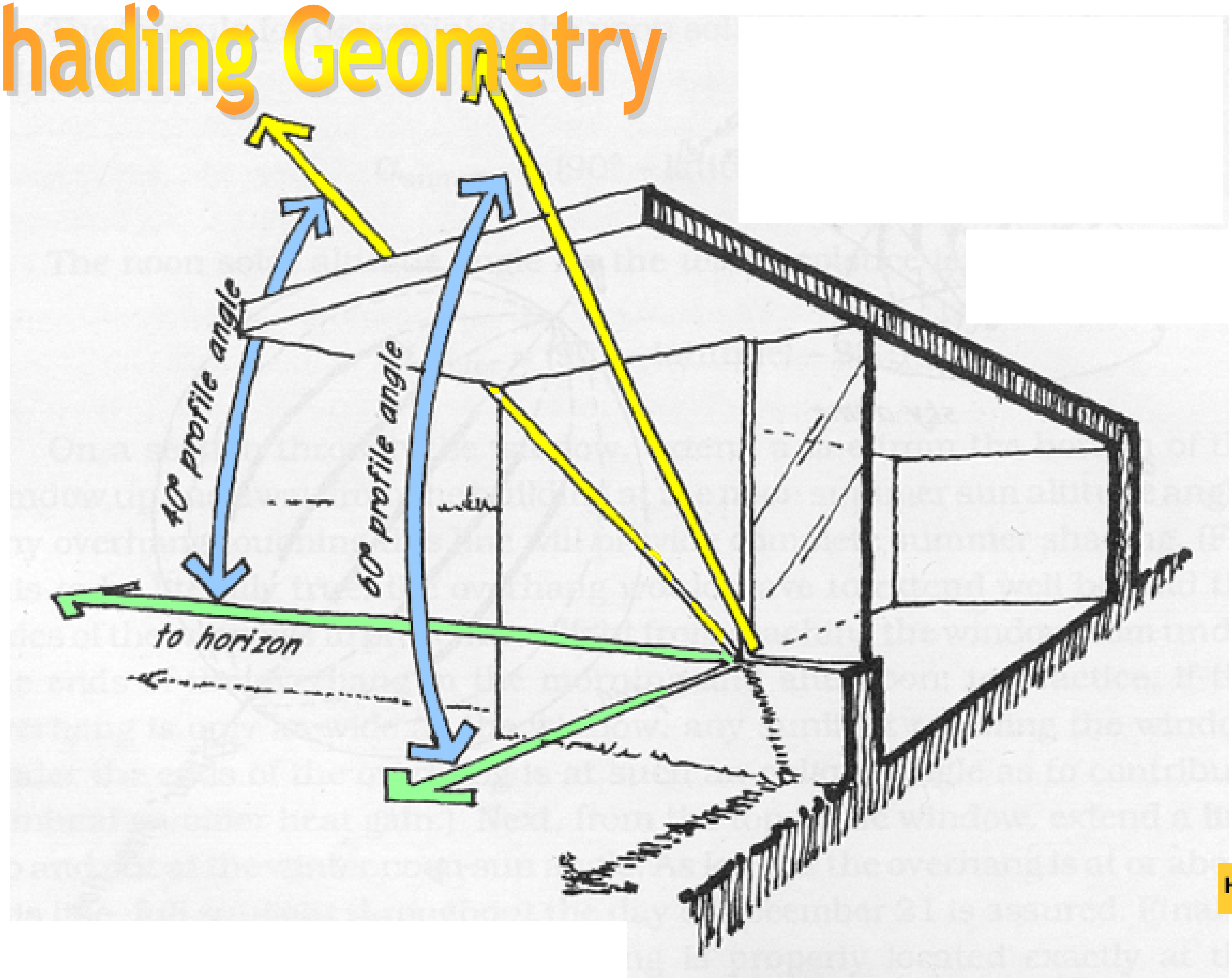
Image: Evelyn Hoffman

Shading Geometry



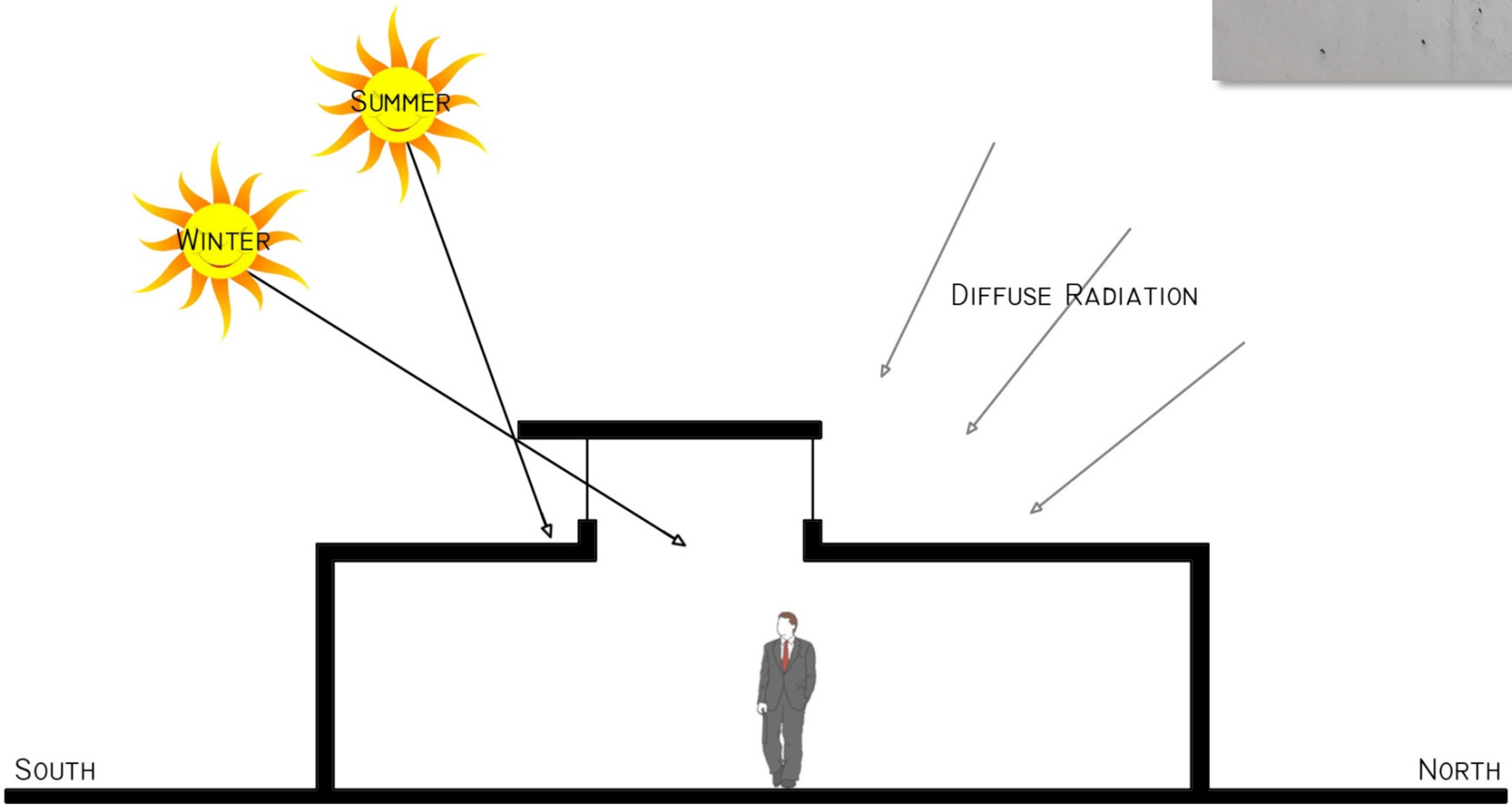
HCL

Shading Geometry



HCL

A simple roof overhang
acts as a shading device.



Clerestory Window

Shading Geometry

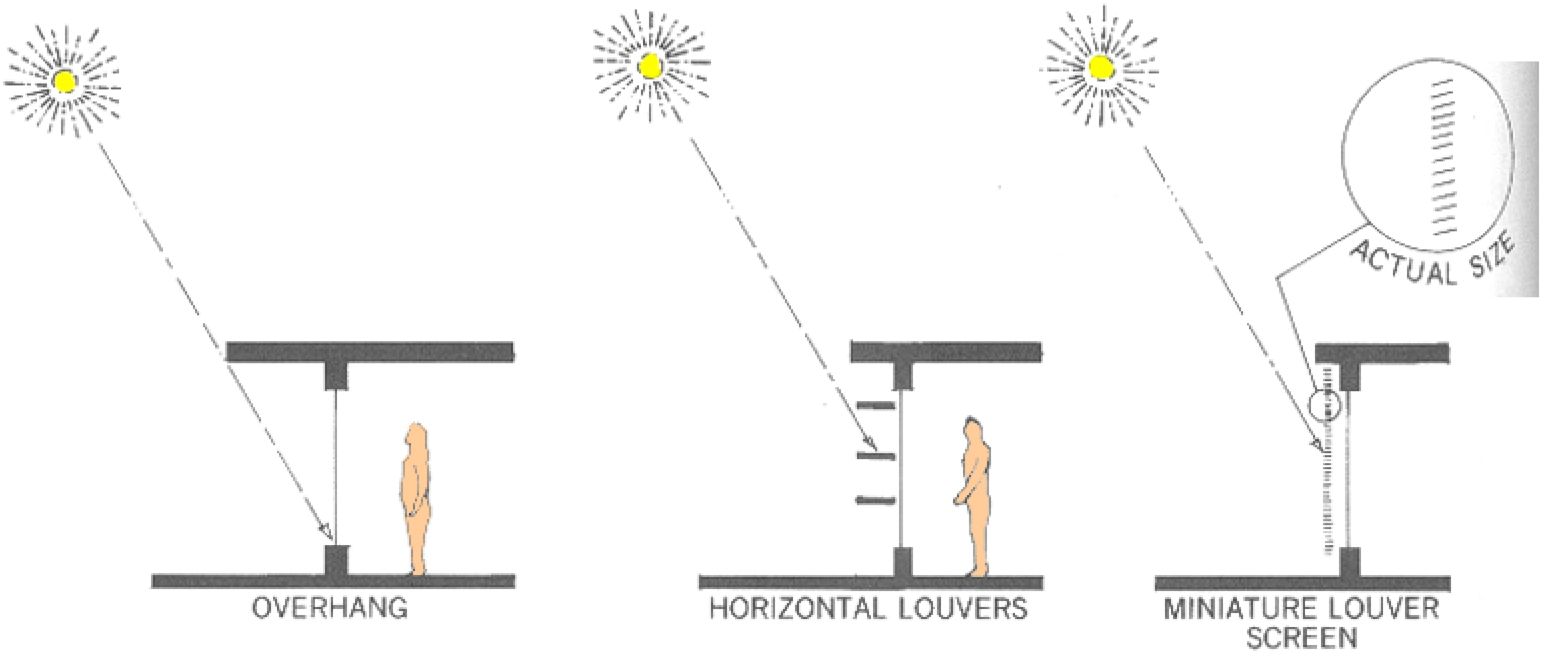
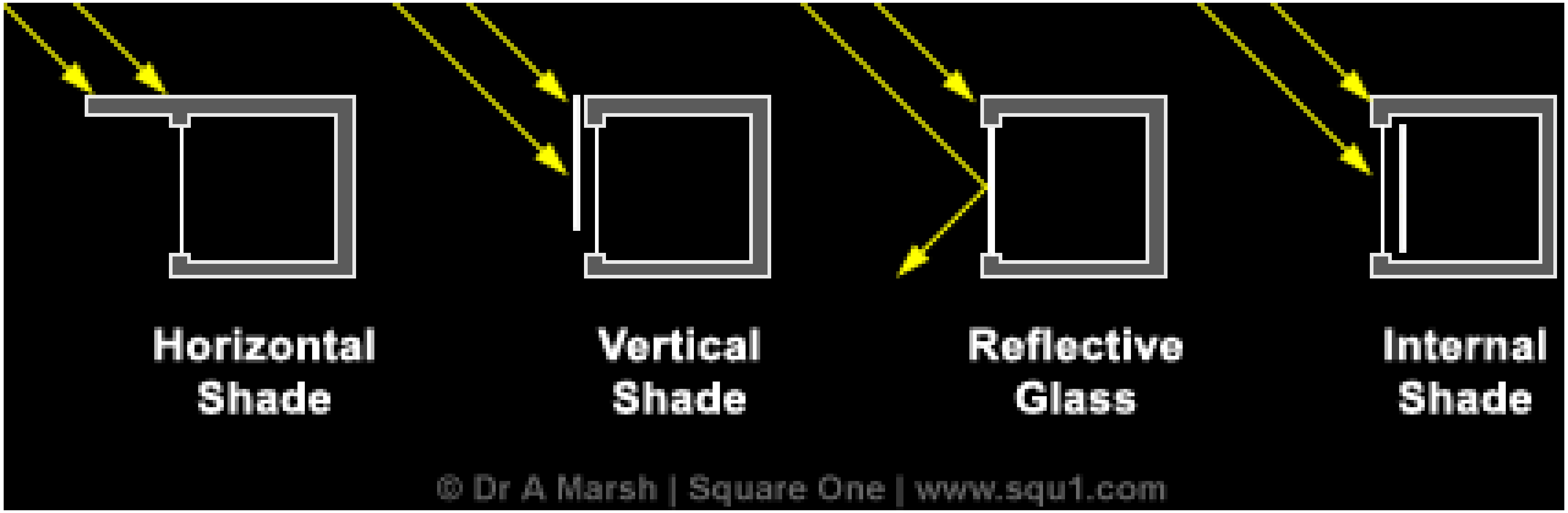


Figure 9.3d Many small elements can create the same shading effect as one large device. However, the view is best with the large overhang.

HCL

Basic shading types



Which ones compromise the view? These also compromise daylight and natural light to the room.

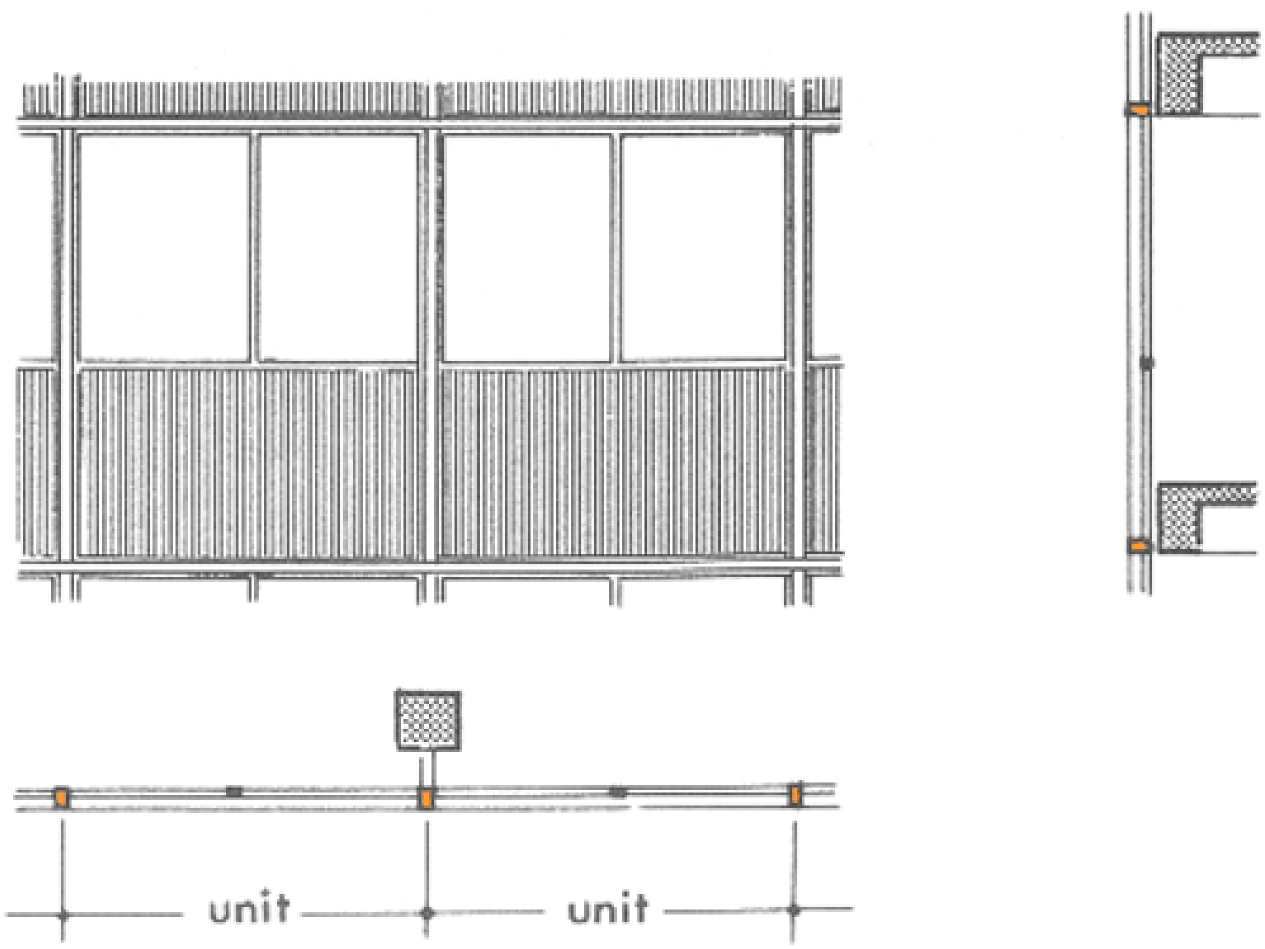
Shading Devices are Not "New"...

Ministry of Education, Rio De Janeiro (southern hemisphere)

Le Corbusier used his “Brise Soleil” to shade the façades of the Unite d’Habitation (northern hemisphere).

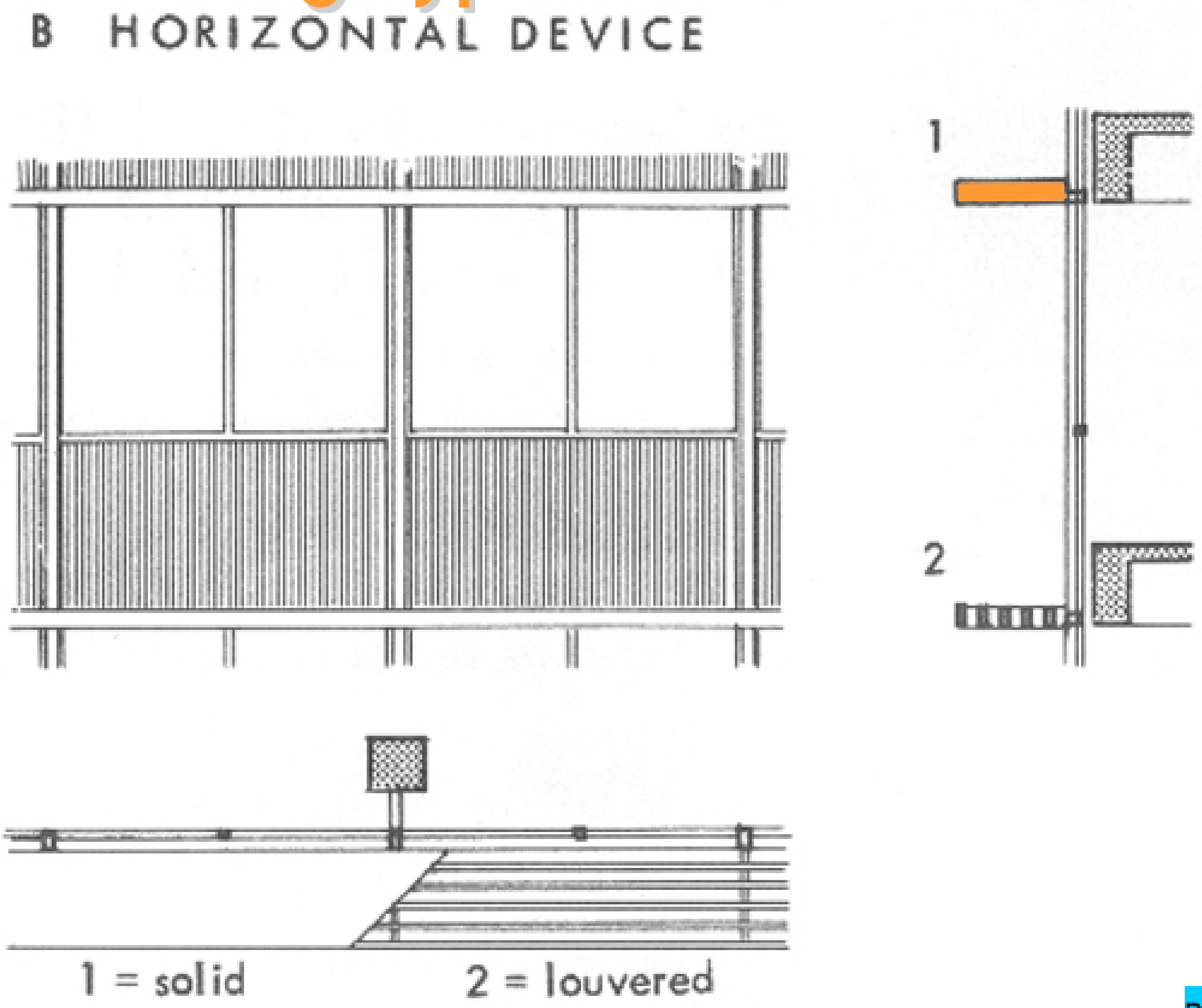
Basic Shading Types

A CURTAIN WALL



DWC

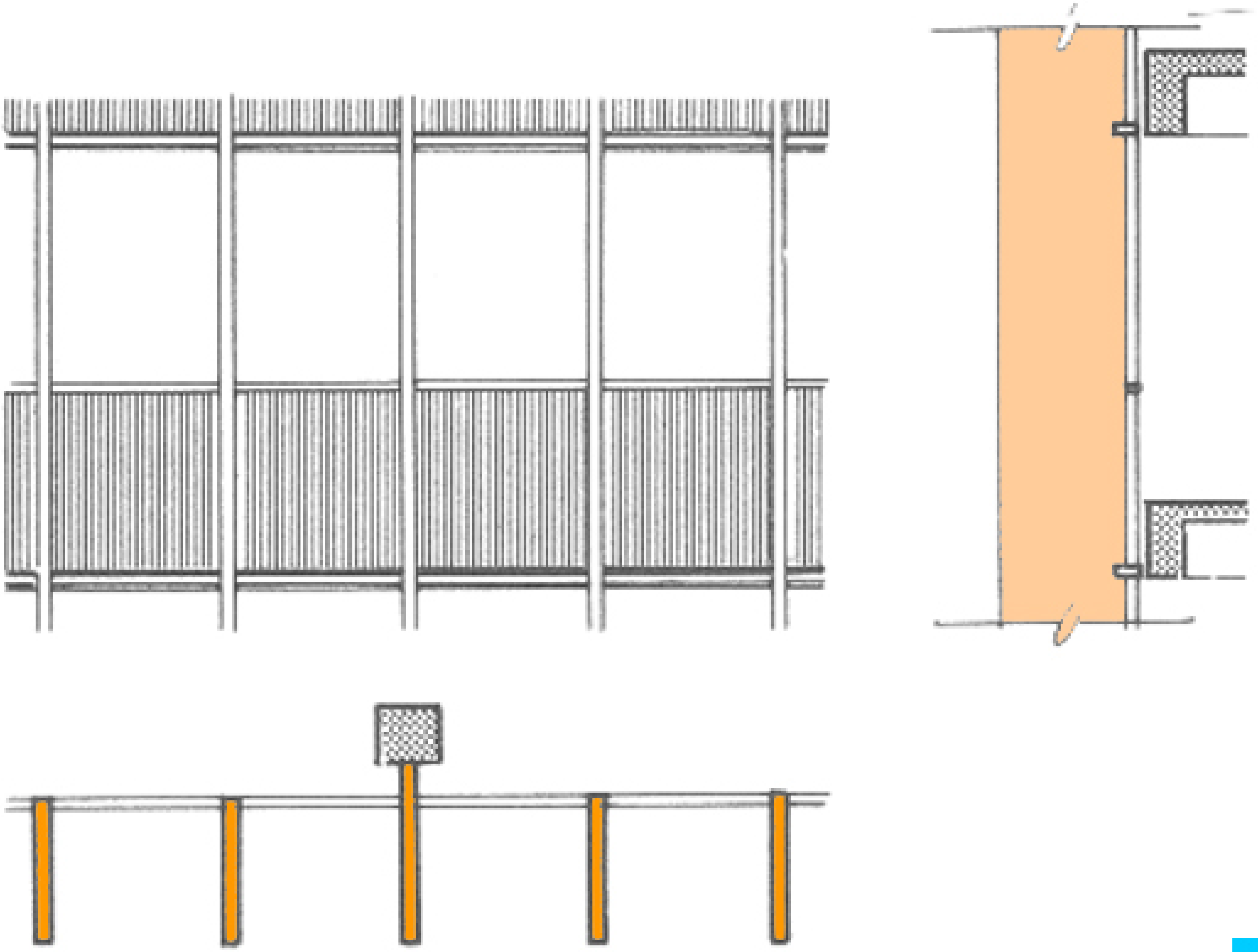
Basic Shading Types



DWC

Basic Shading Types

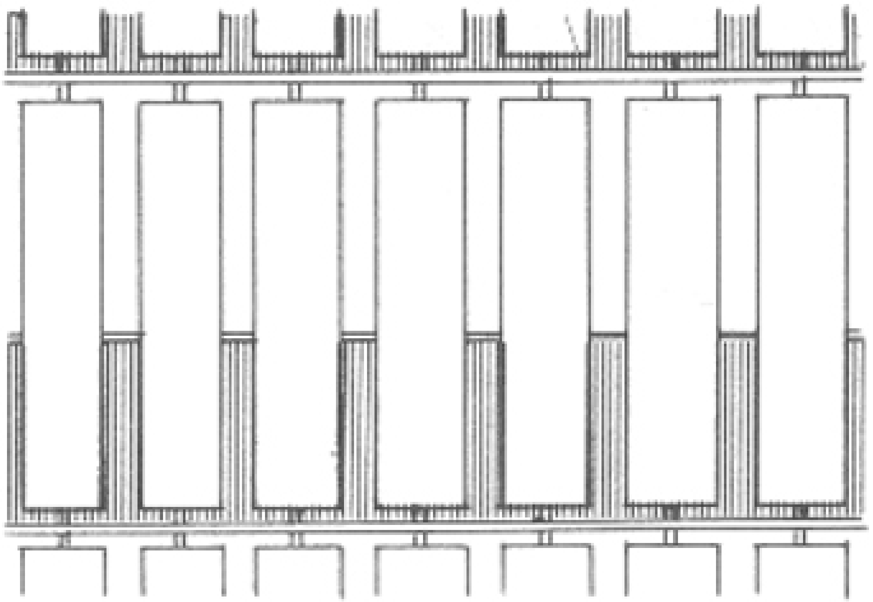
C VERTICAL FIN

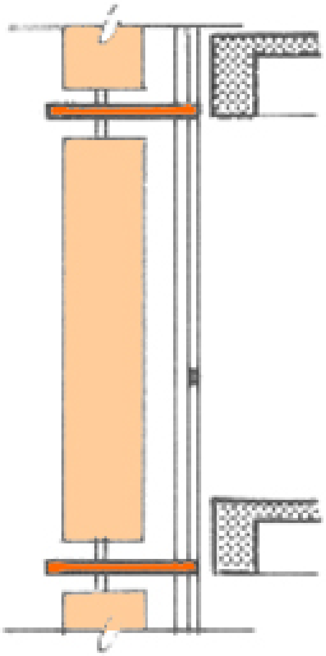


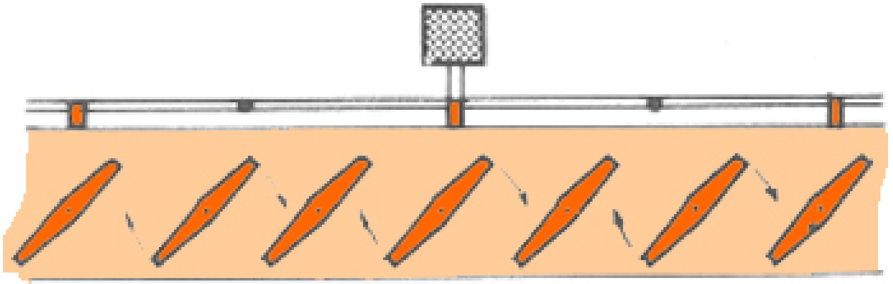
DWC

Basic Shading Types

D VERTICAL MOVABLE



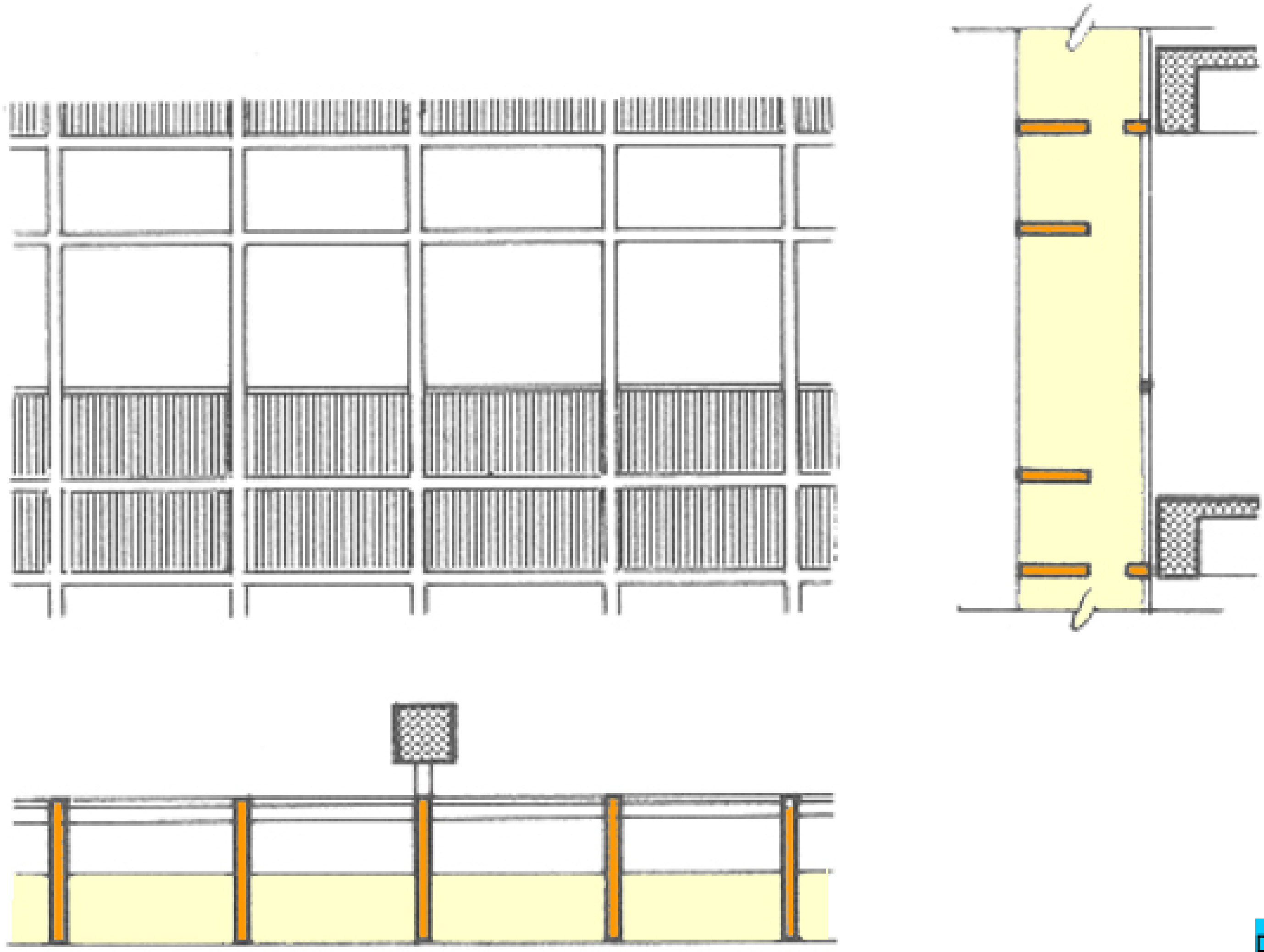




DWC

Basic Shading Types

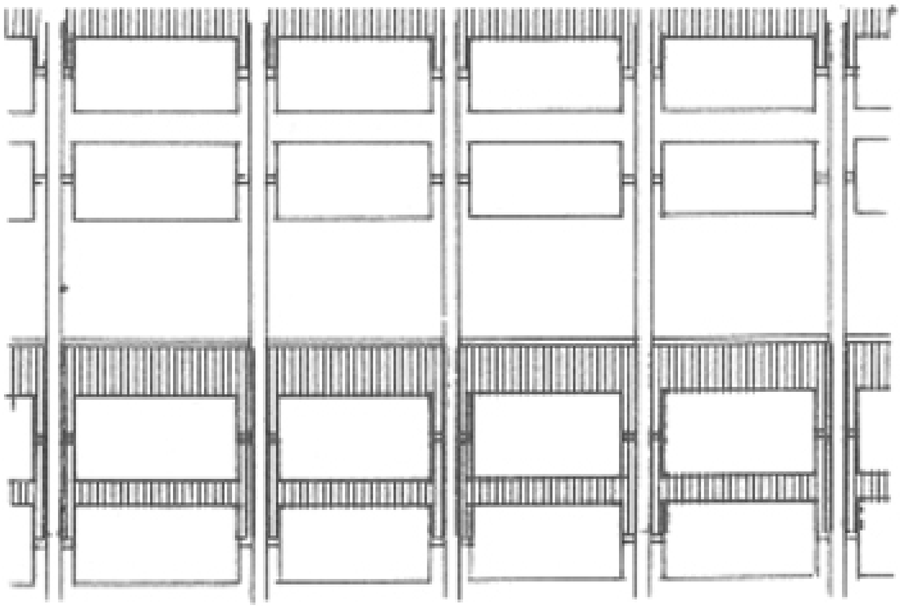
E FIXED EGGCRATE

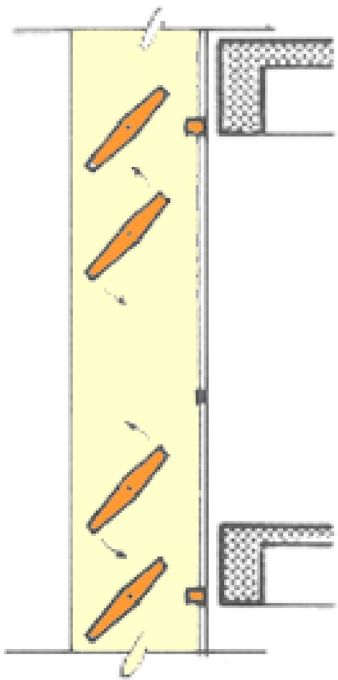


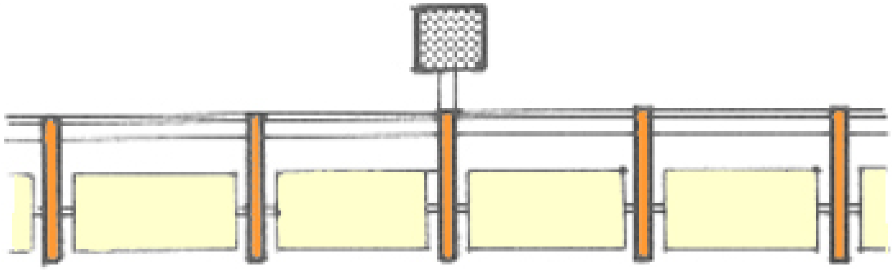
DWC

Basic Shading Types

F MOVABLE EGGCRATE







Even though the grate is removed from the building face, its net effect is somewhat the same.

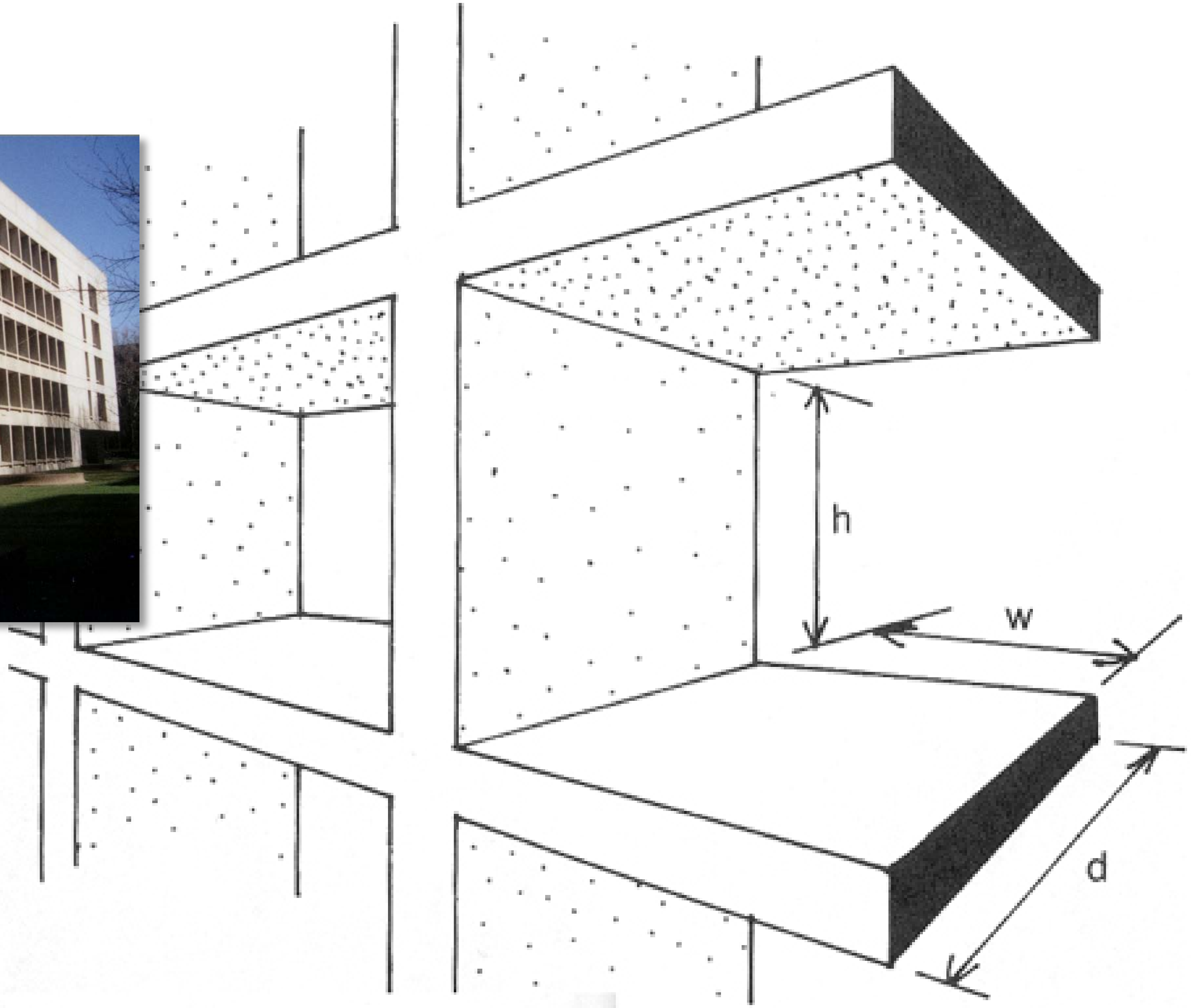
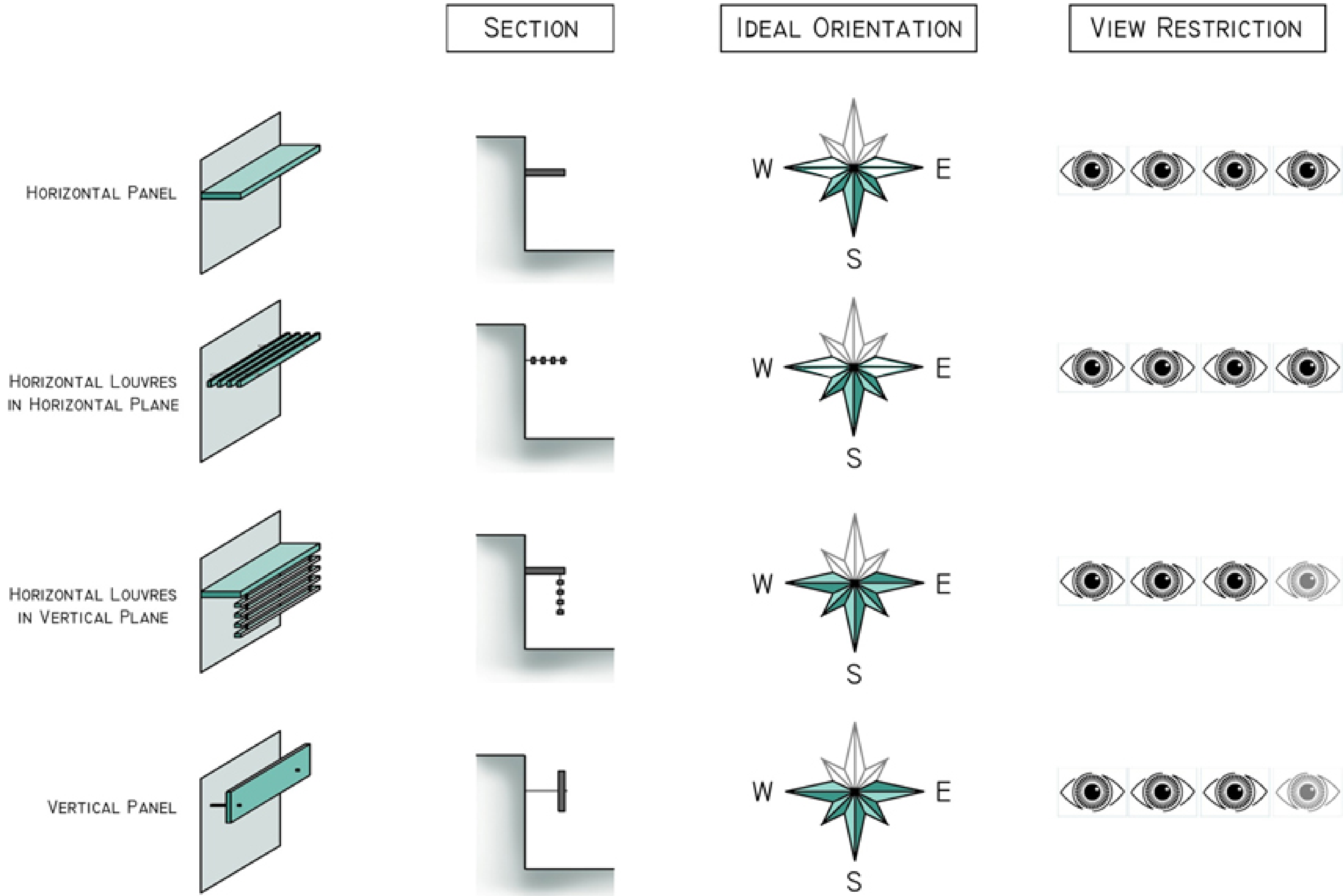
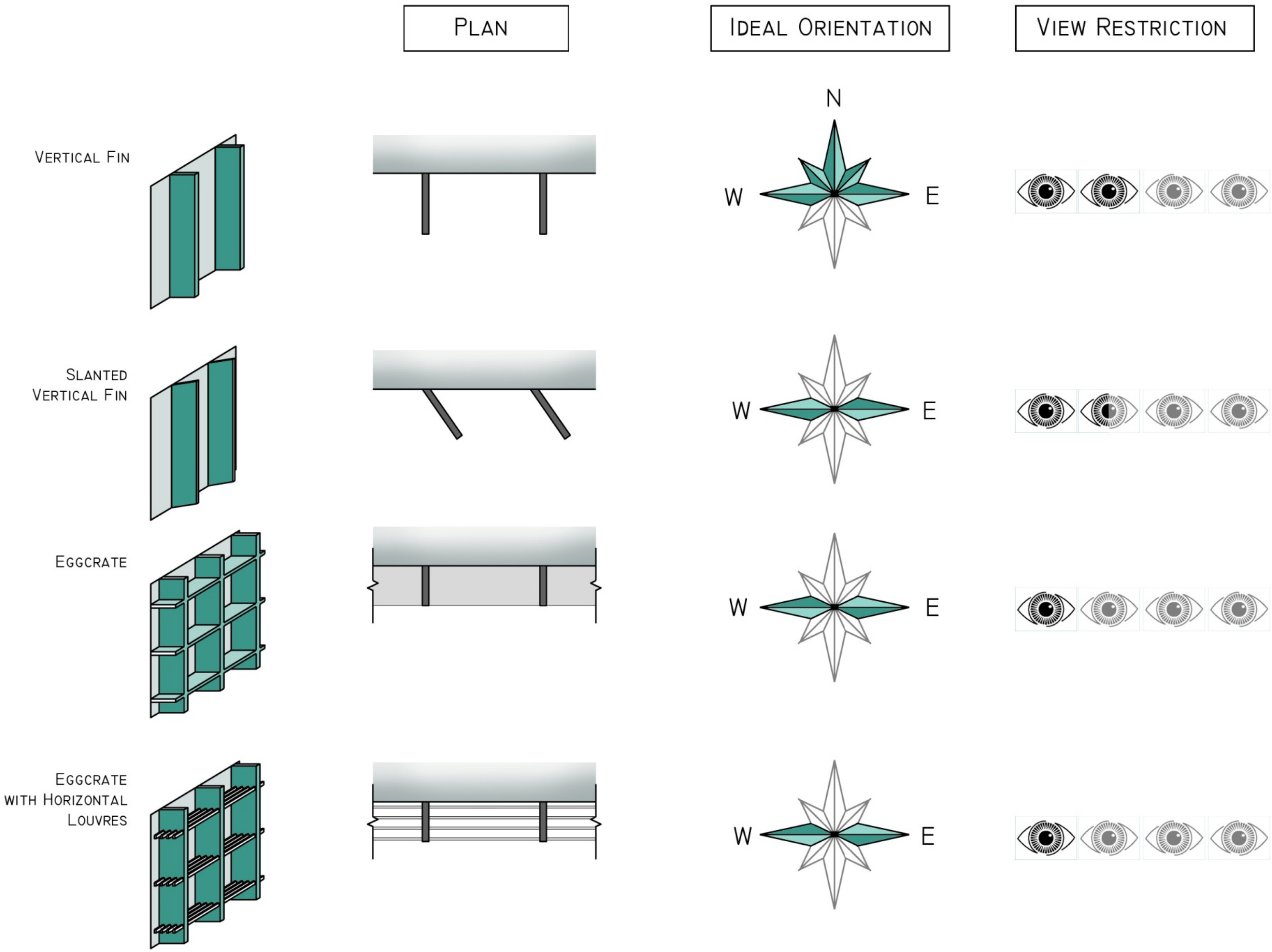


Figure 9.14d The shading effect is a function of the ratios h/d and w/d. It is not a function of actual size.

HCL


Section
Ideal Orientation
View Restriction
Horizontal Panel
Horizontal Louvres in Horizontal Plane
Horizontal Louvres in Vertical Plane
Vertical Panel
W
E
S



PLAN
IDEAL ORIENTATION
VIEW RESTRICTION
VERTICAL FIN
N
W
E
SLANTED VERTICAL FIN
W
E
EGGCRATE
W
E
EGGCRATE WITH HORIZONTAL LOUVRES
W
E

Solar Geometry tells us that we need different shading strategies for each façade ...

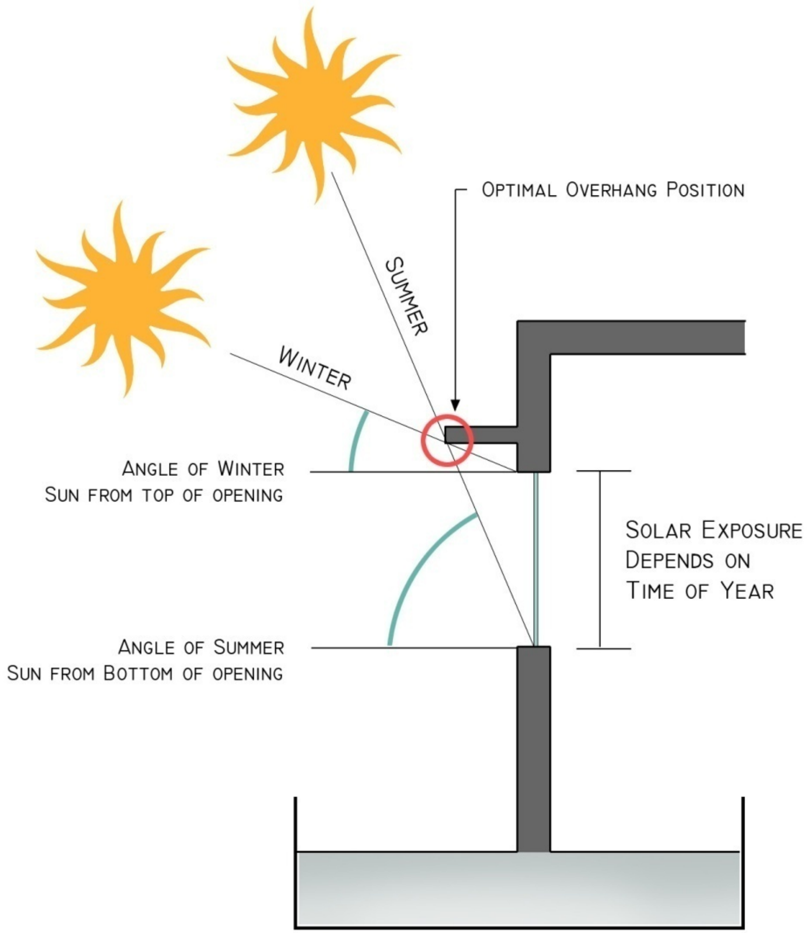
South Facing Shading Strategies

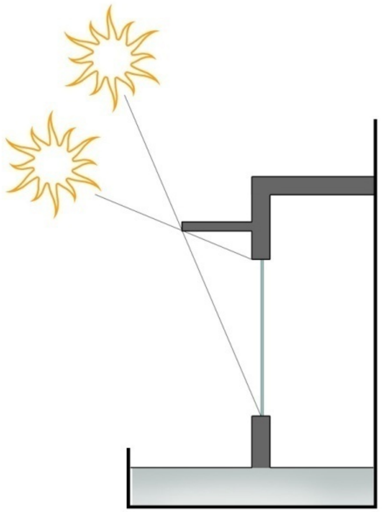
Solar Exposure of Window is a Function of:

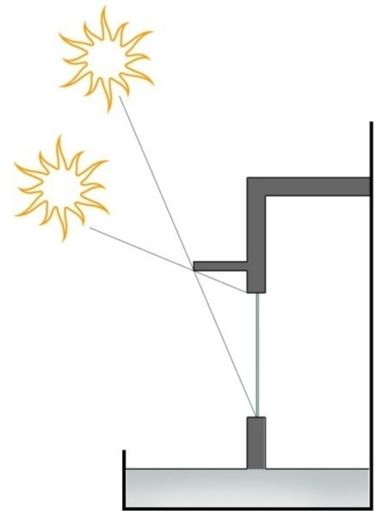
Time of Year

vs.

Temperature







A variety of approaches is possible.

Louvered shades are commonly used to:

- prevent snow build up
- allow for ventilation at the façade
- lighter when it comes to loading and support than solid shades

Differentiated Shading Strategies

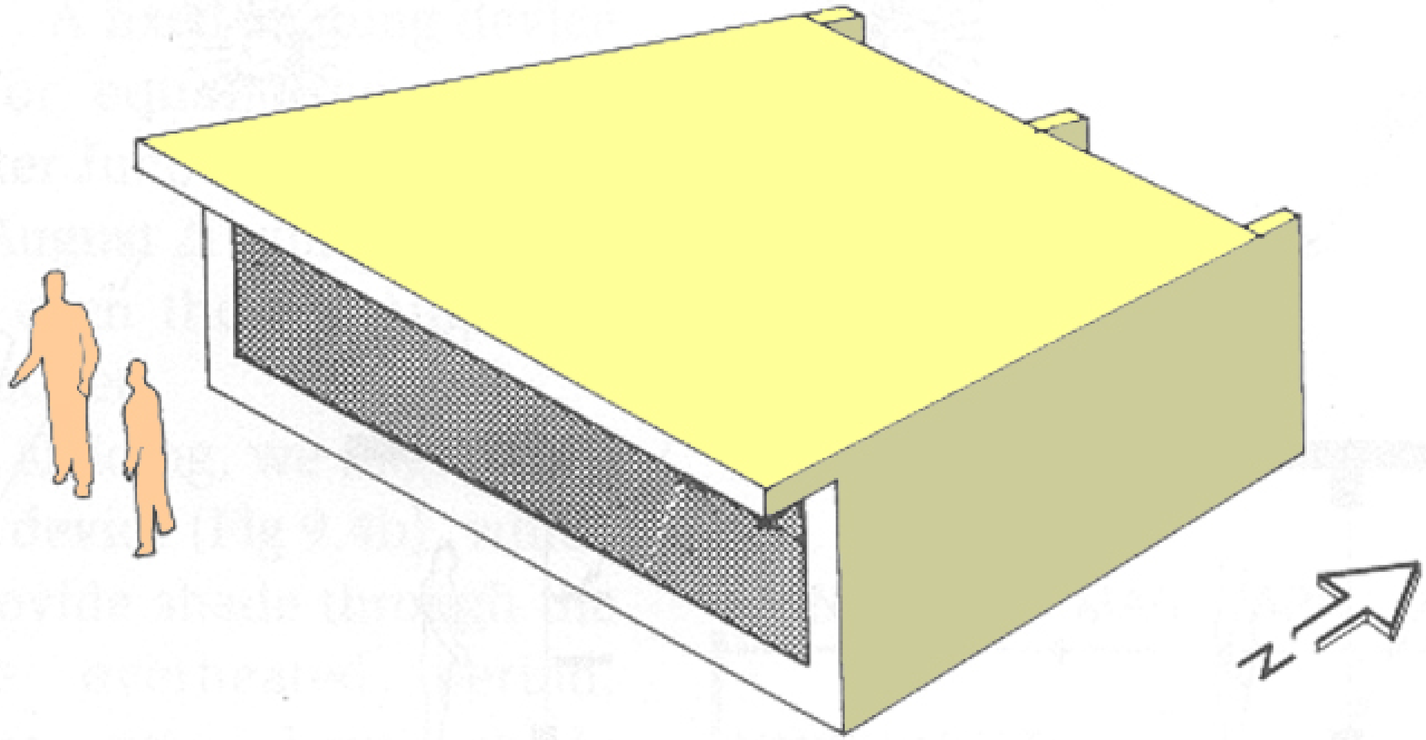


Figure 9.3a Each orientation requires a different shading strategy.

HCL

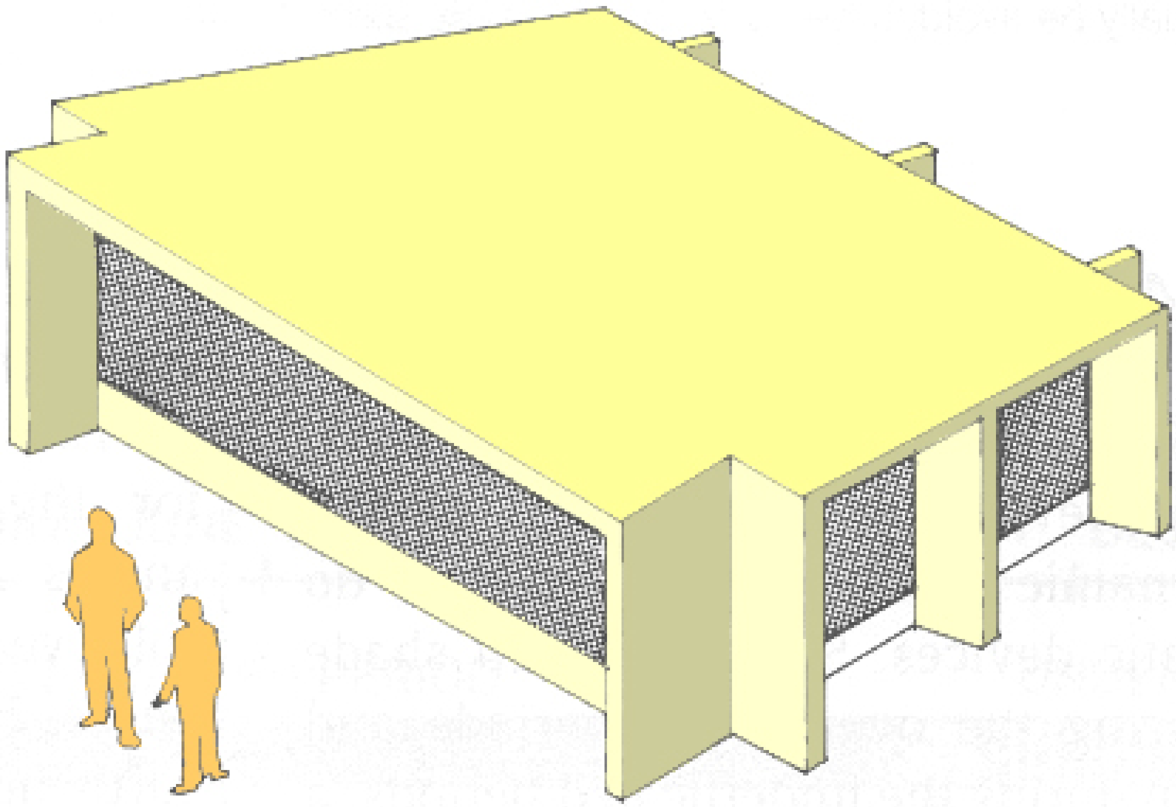
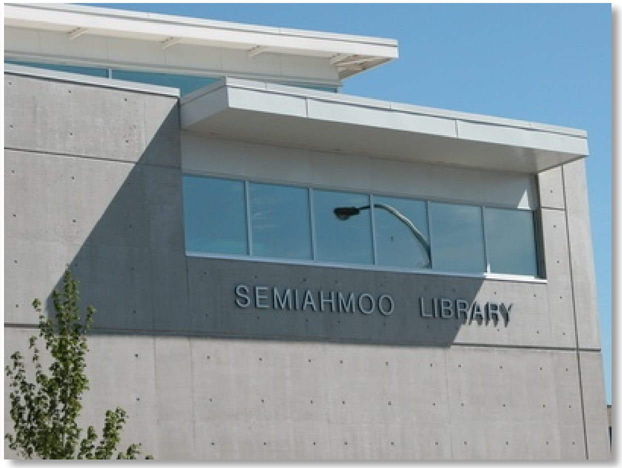
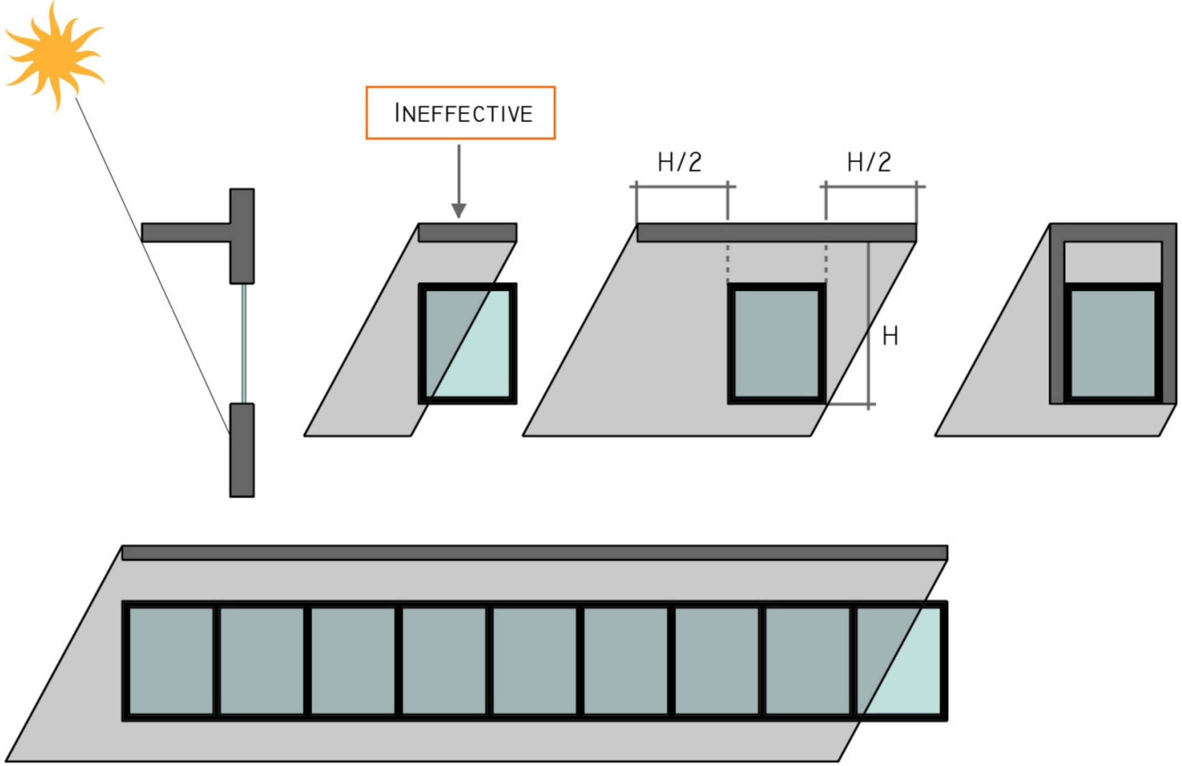


Figure 9.3c Shading is improved when a combination of vertical and horizontal elements is used.

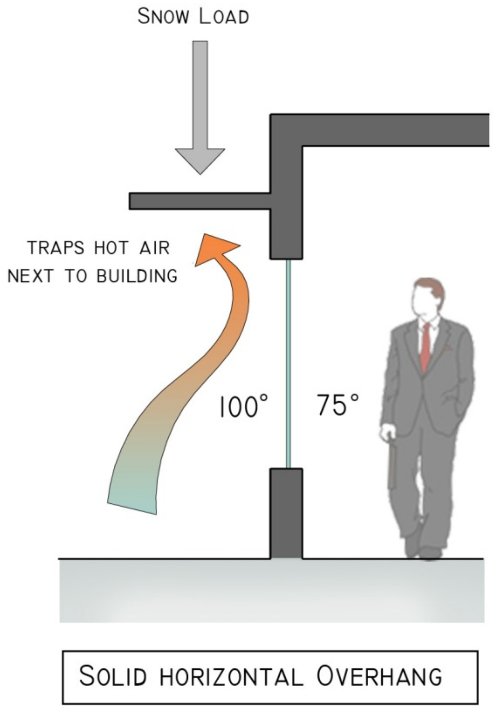
HCL

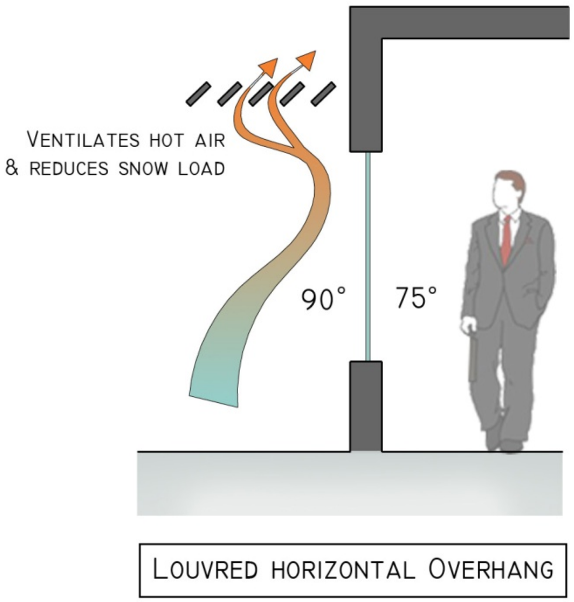


...extend device for full shading



This one uses ceramic fritted glass that is sloped, to allow some light but shed rain and wet snow.



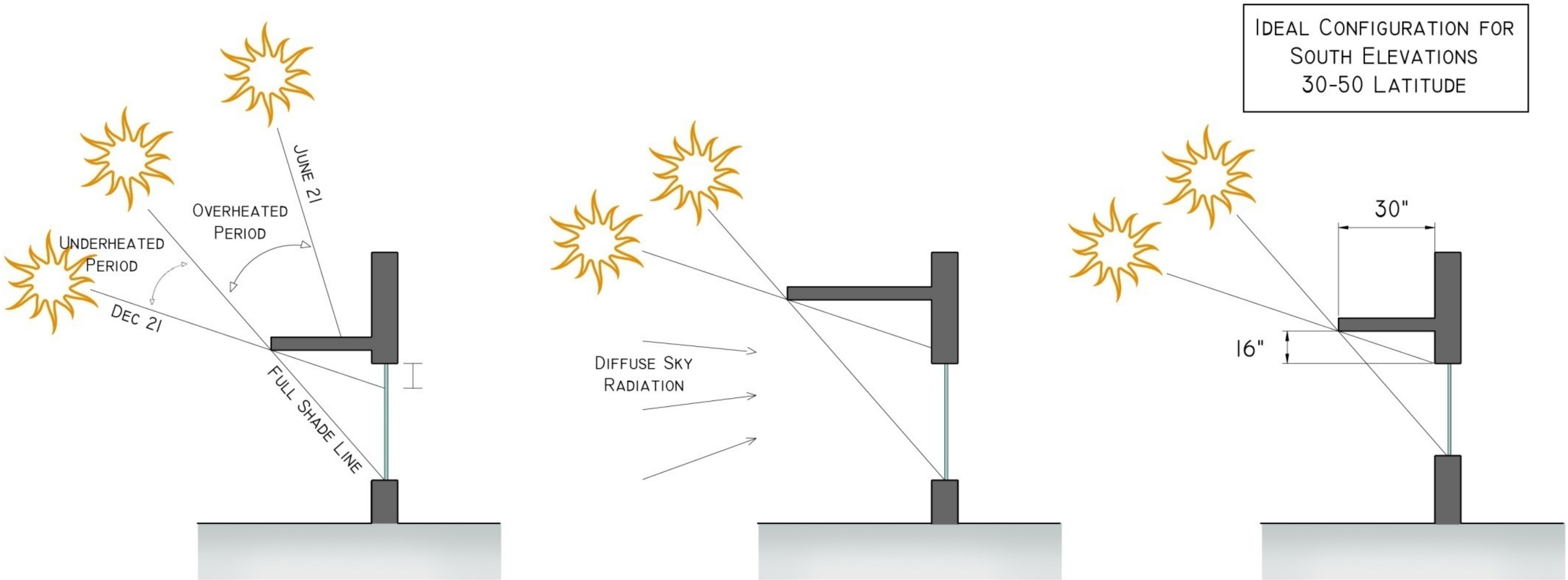


The above two use louvers or grates that will let snow, rain and wind through.

Preventing overheating

A problem inherent in any fixed overhang is its inability to respond to seasonal lag. The warmest period of the summer occurs in early August about 5 or 6 weeks after the summer solstice (June 21 when the sun is highest in the sky). A fixed overhang designed to provide complete shading on June 21 allows unwanted sunlight to enter the window when the daily temperatures are warmest five weeks later.

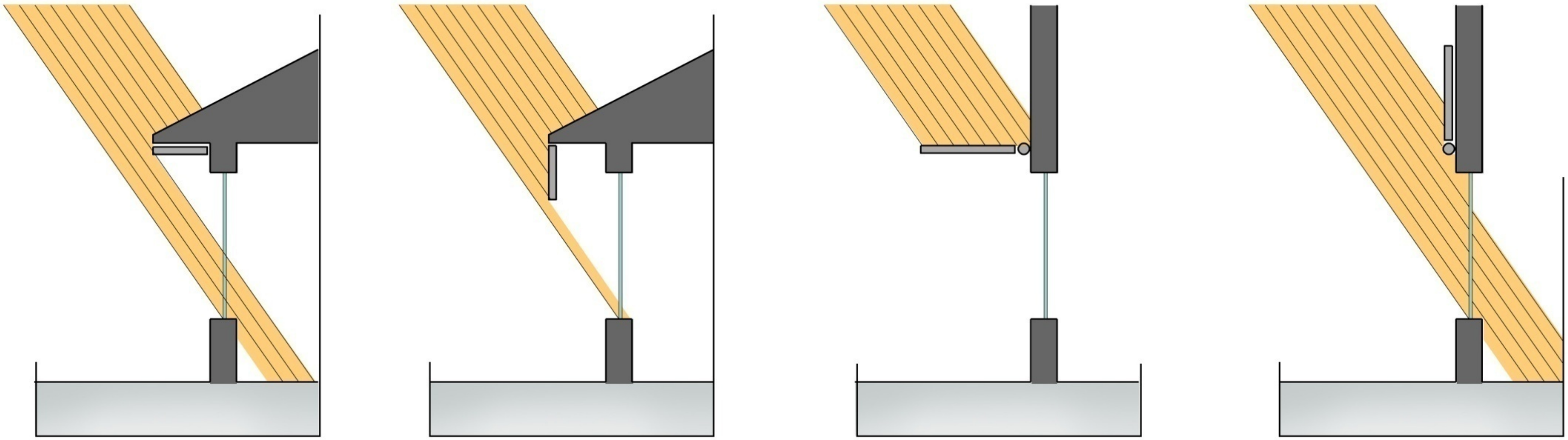
Conversely designing to provide complete shading during the warmest period (in early August) also results in similar complete shading from mid-May when solar heat may still be desirable.



High overhangs are not recommended for humid climates because of the excess of diffuse sky radiation

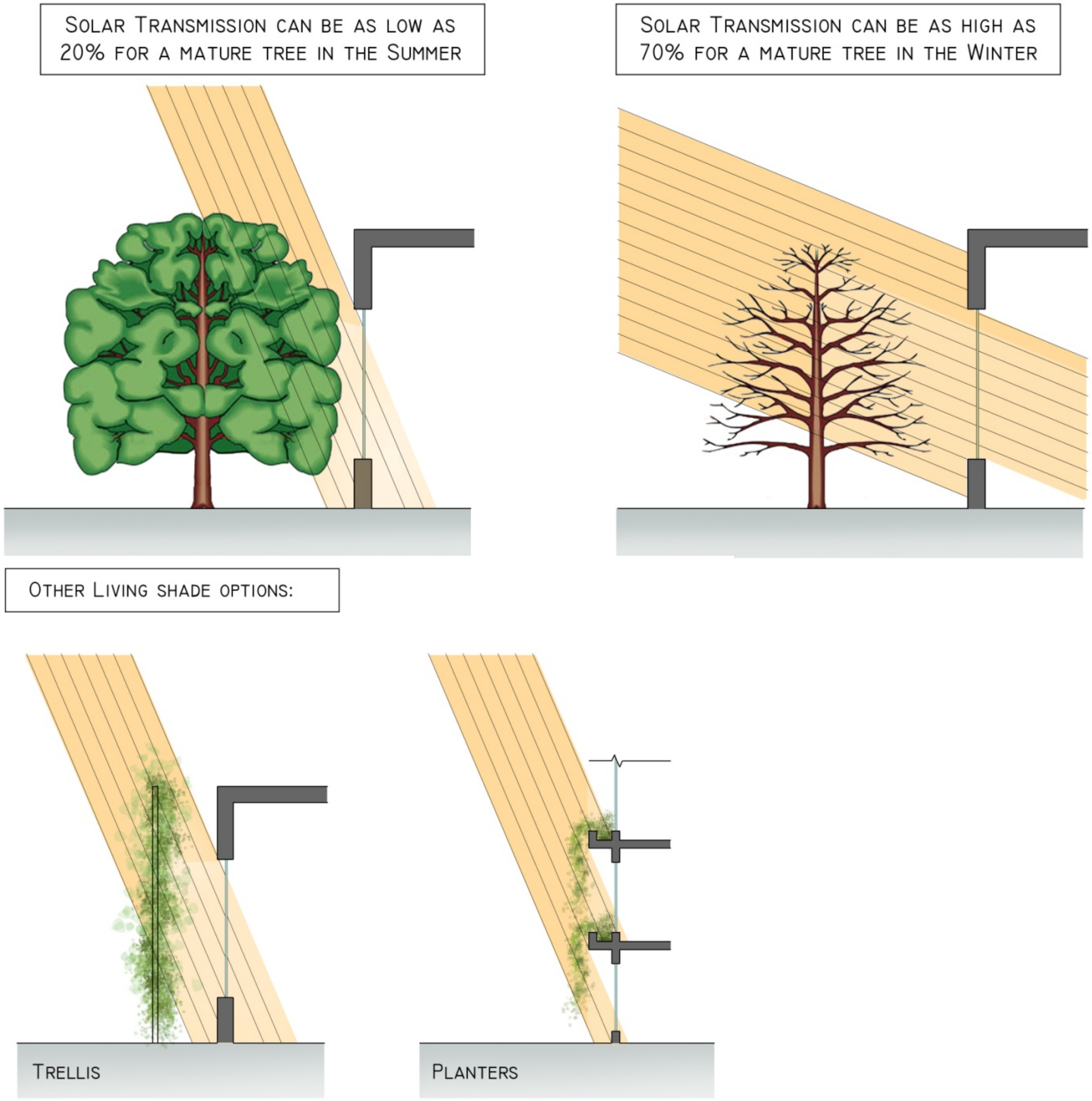
Adjustable overhangs provide a solution to seasonal lag.

Some ideas might work well "in a drawing", but think carefully before you use any devices that require hinges or motion in climates where snow and ice will cause wear.



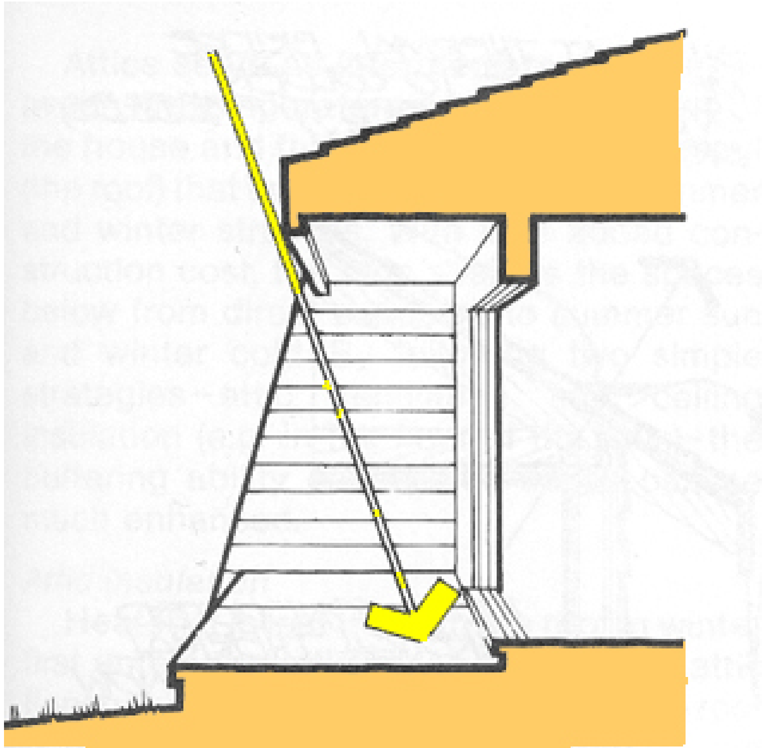
IN THEORY, A HINGED, TWO-POSITION SHADING DEVICE AN EFFECTIVE SOLUTION.
... BUT CONSIDER ITS PRACTICALITY.

Living Awnings such as deciduous trees and trellises with deciduous vines are very good shading devices. They are in phase with the thermal year – gain and lose leaves in response to temperature changes.

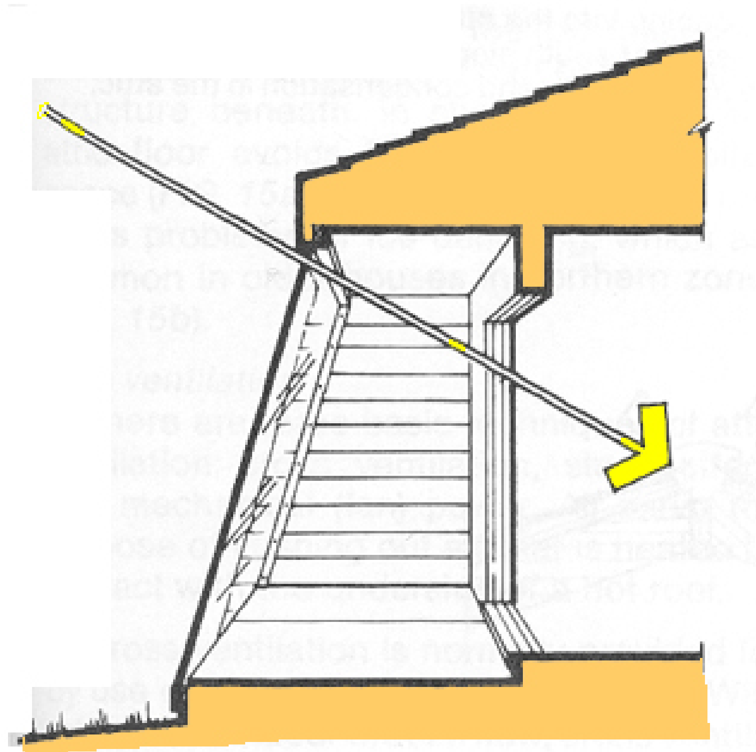


Center for Regenerative Studies, Cal Poly Pomona

Ketchum Residence, ON, Sustainable EDGE Inc.



SIZE OVERHANG FOR SUMMER SUN PROTECTION



IF PROPERLY PLANNED IN ADVANCE, A SEASONAL GREENHOUSE CAN BE ADDED BY "STITCHING" IN A PLASTIC FILM TO SOFFIT, CURB, AND WINGWALL NAILING STRIPS.

FIG. 14 Outdoor spaces can be designed for both summer sun protection and winter sun collection with demountable glazing panels or films.

CBD

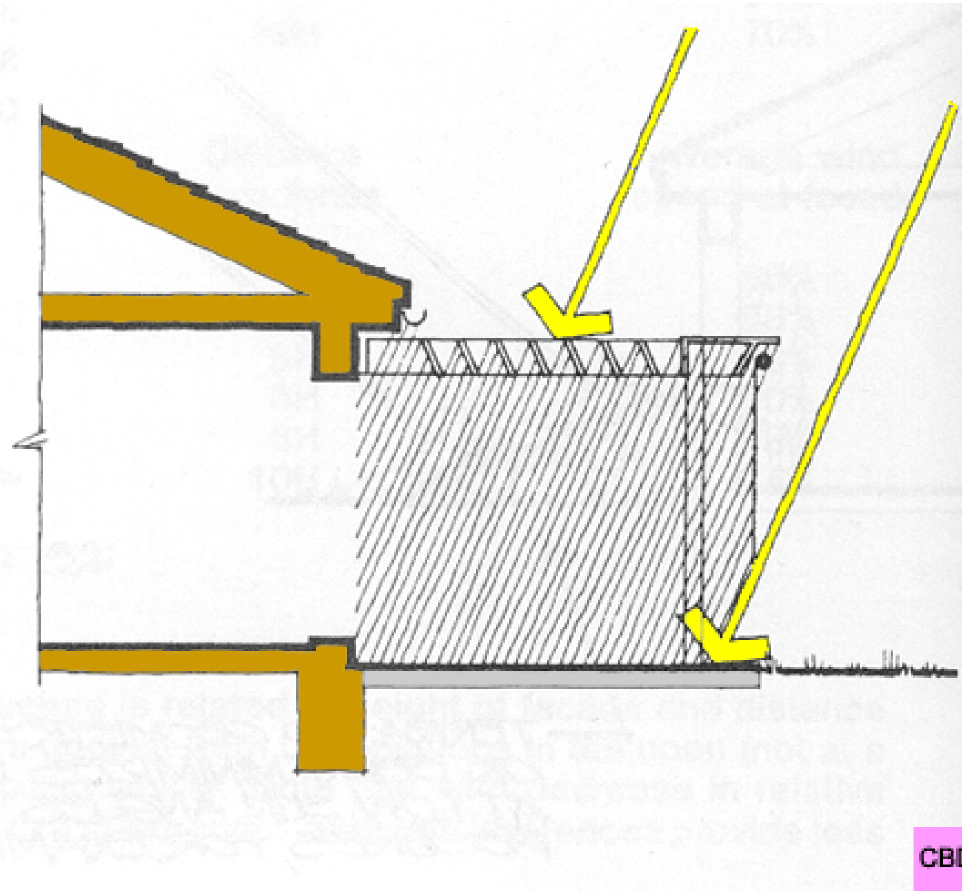
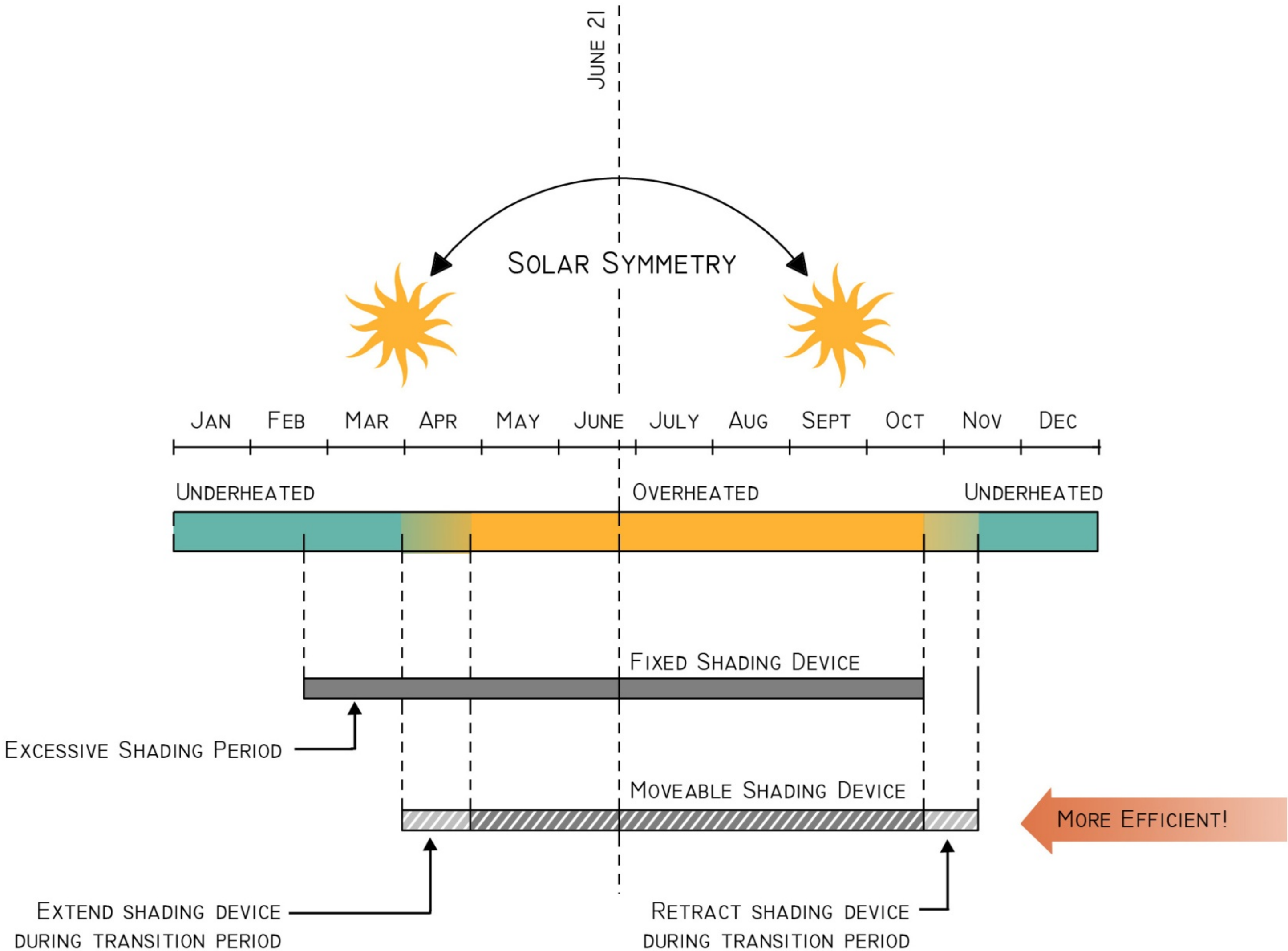


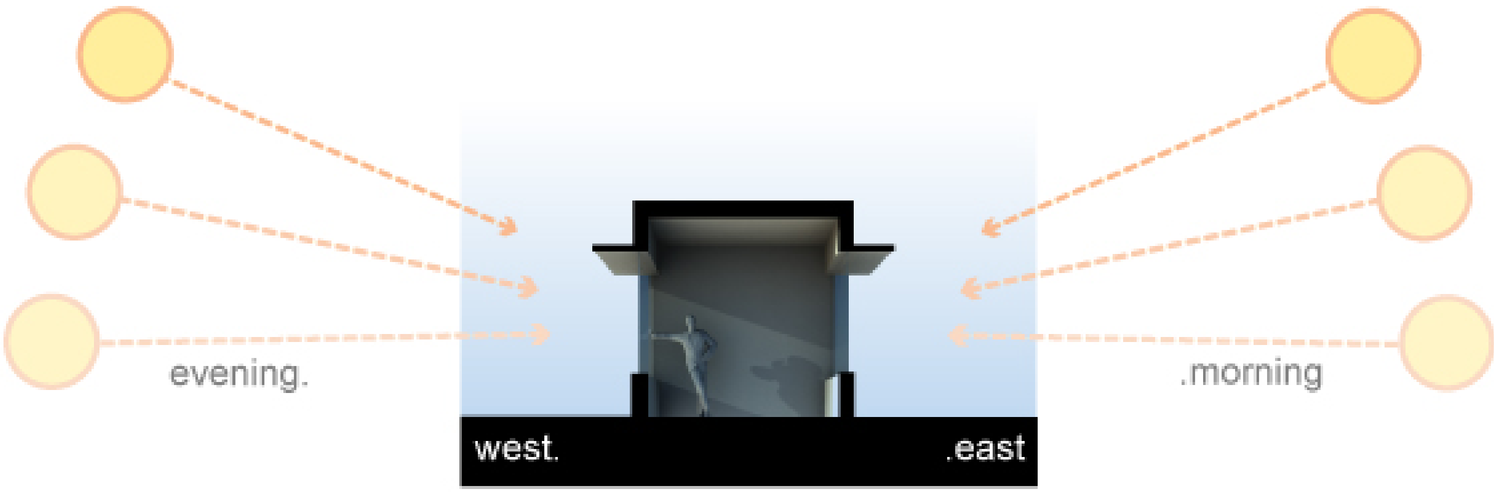
FIG. 4d. Attached overhead shading structures can provide multiple benefits. Not only does this patio cover shade the wall, it also reduces reflected gain from loading on the wall.

Preventing overheating

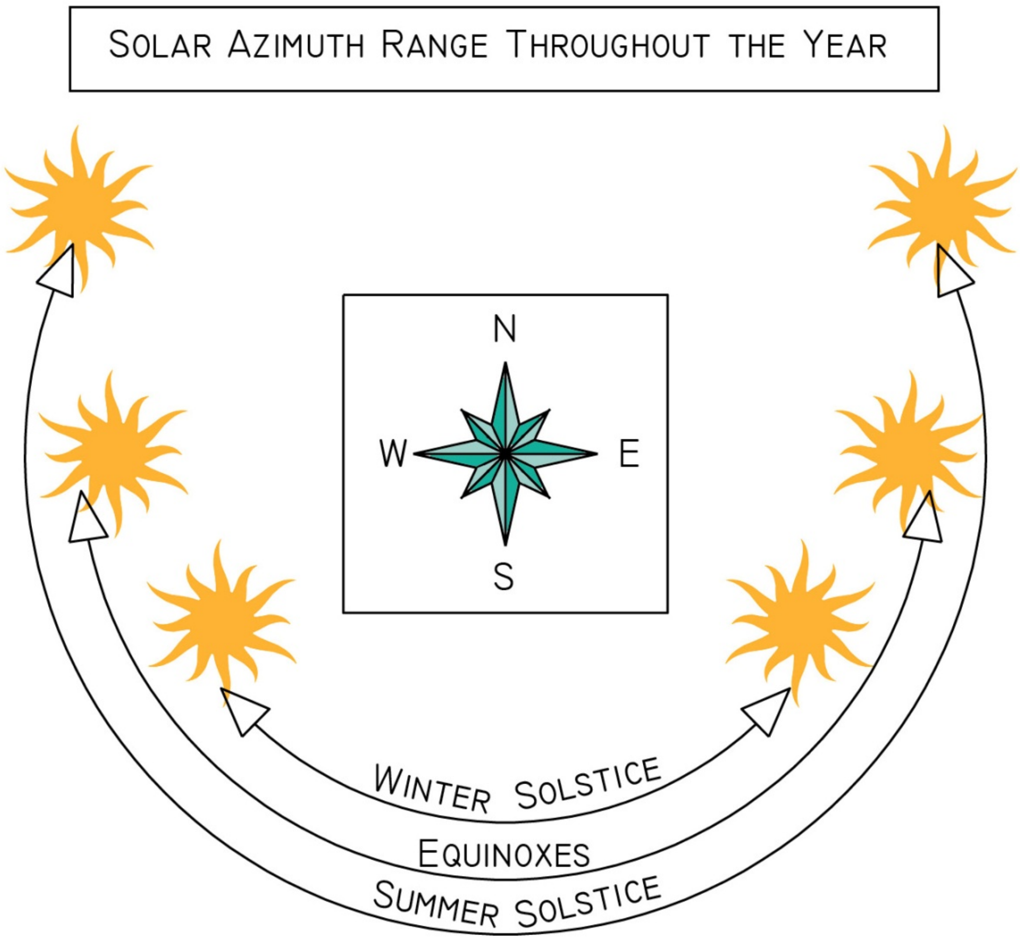


HCL

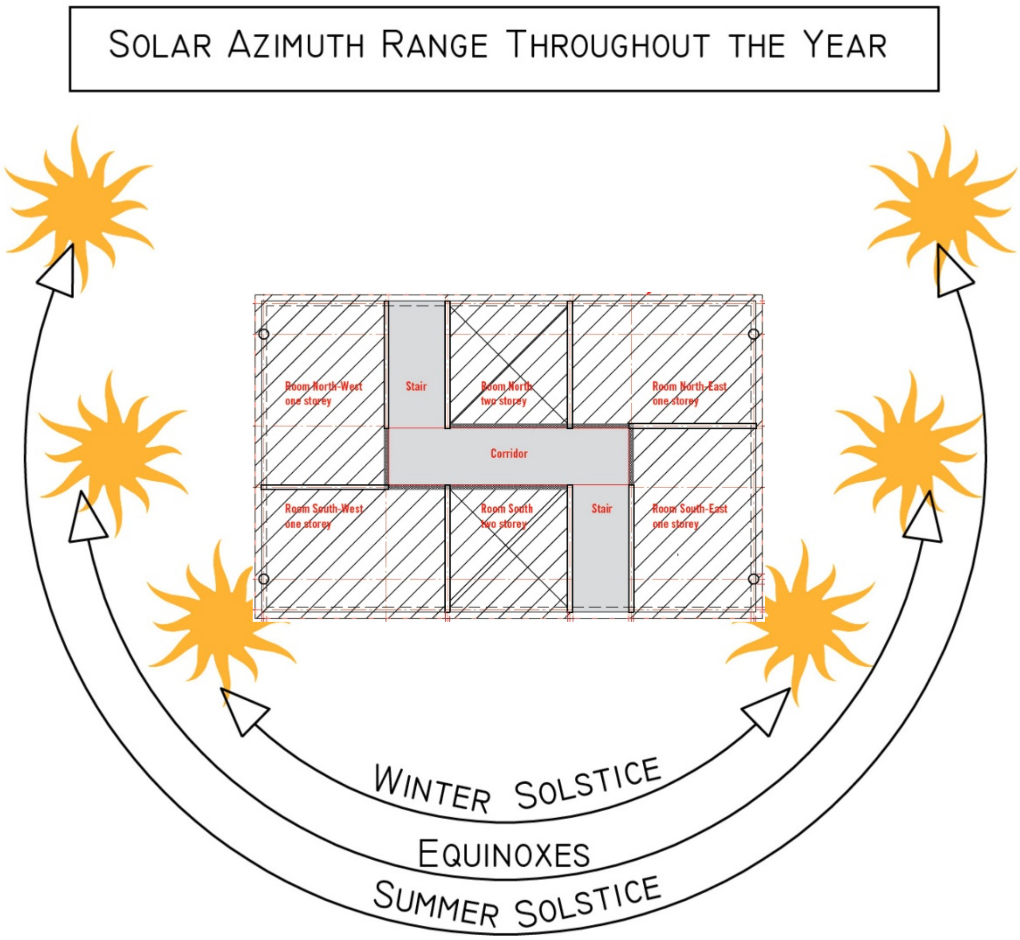
Shading Strategies for West and East Elevations



Horizontal overhangs DO NOT work on east & west facades.

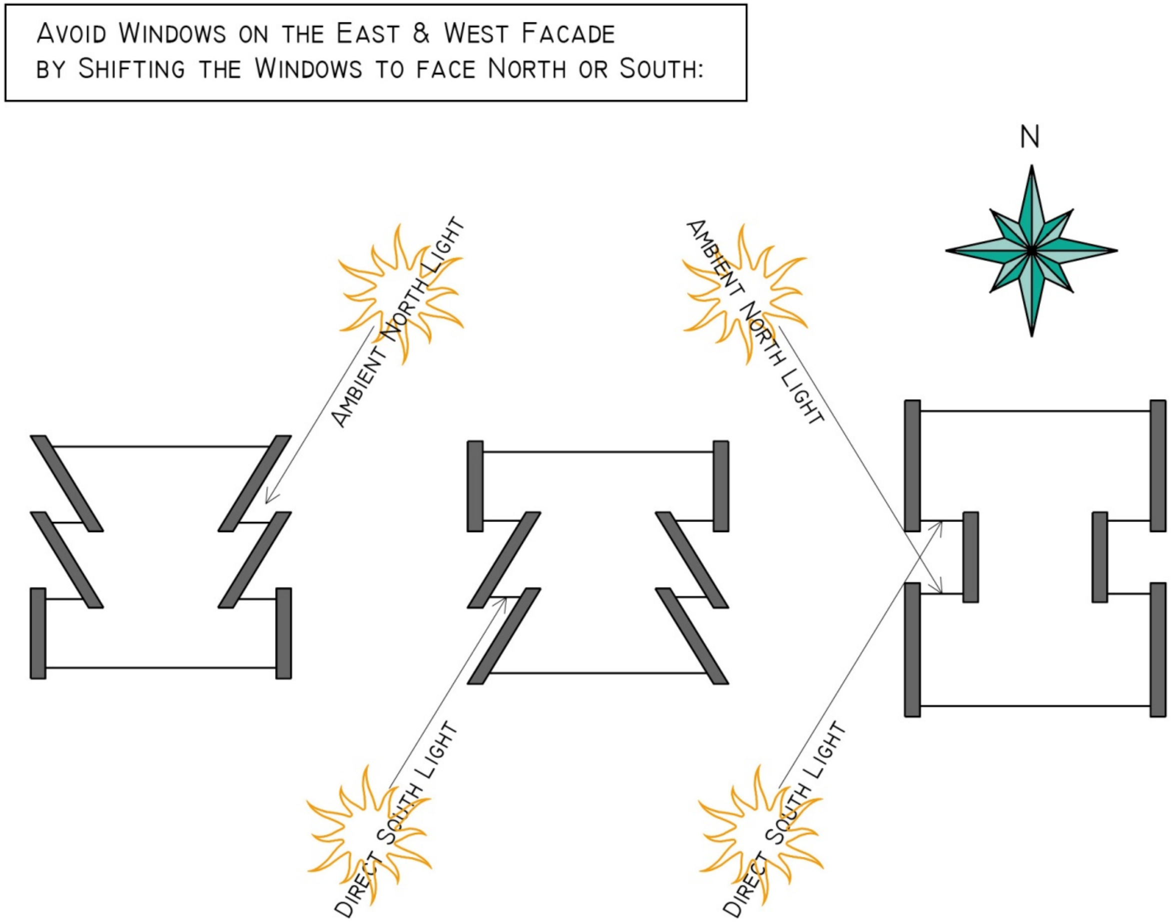


Since little winter heating can be expected from east and west windows, shading devices on those orientations can be designed purely on the basis of the summer requirement.



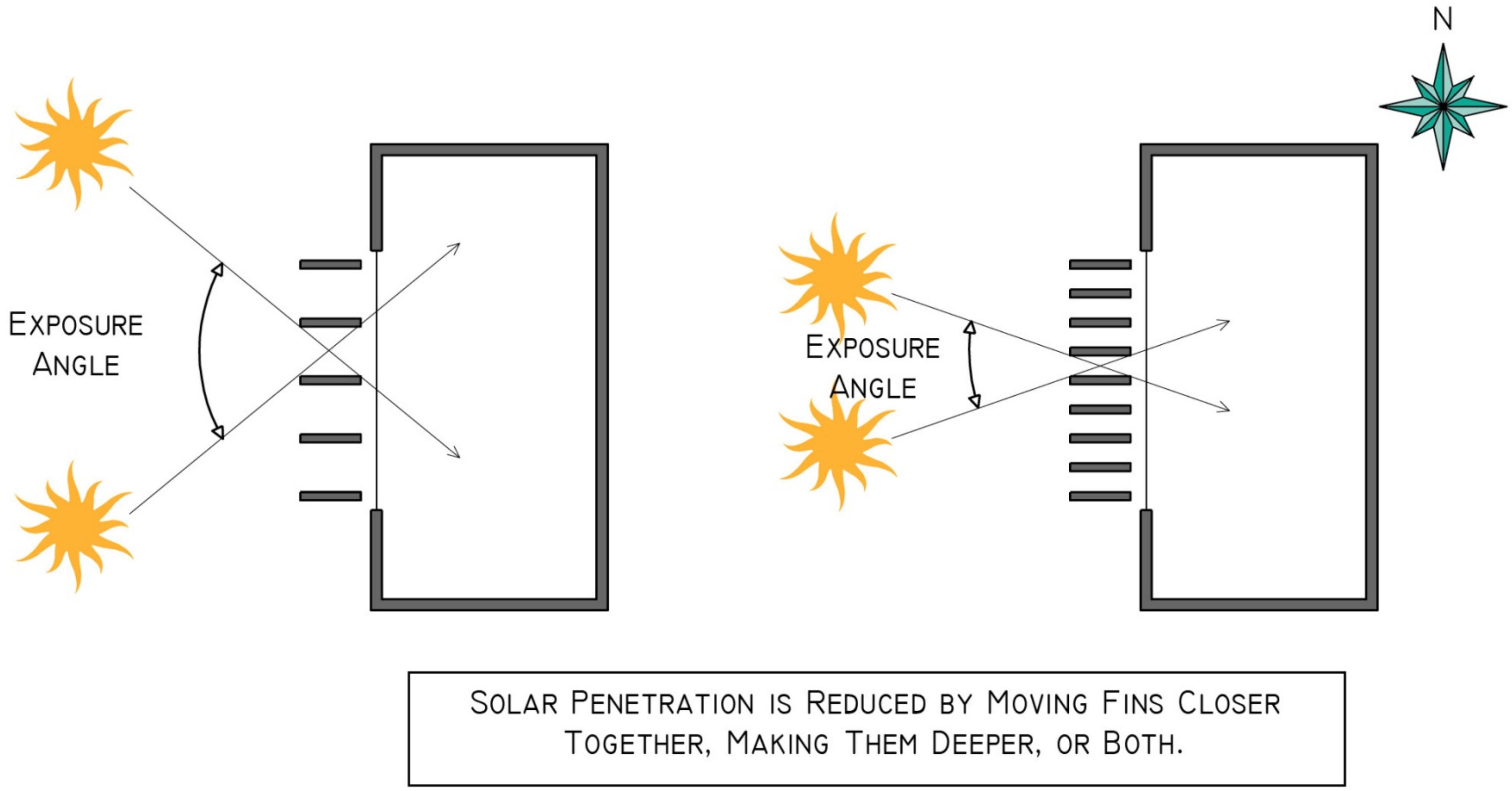
Since little winter heating can be expected from east and west windows, shading devices on those orientations can be designed purely on the basis of the summer requirement.

1. The best solution by far is to limit using east and especially west windows (as much as possible in hot climates)



2. Next best solution is to have windows on the east and west façades face north or south

Shading Strategies for West and East Elevations



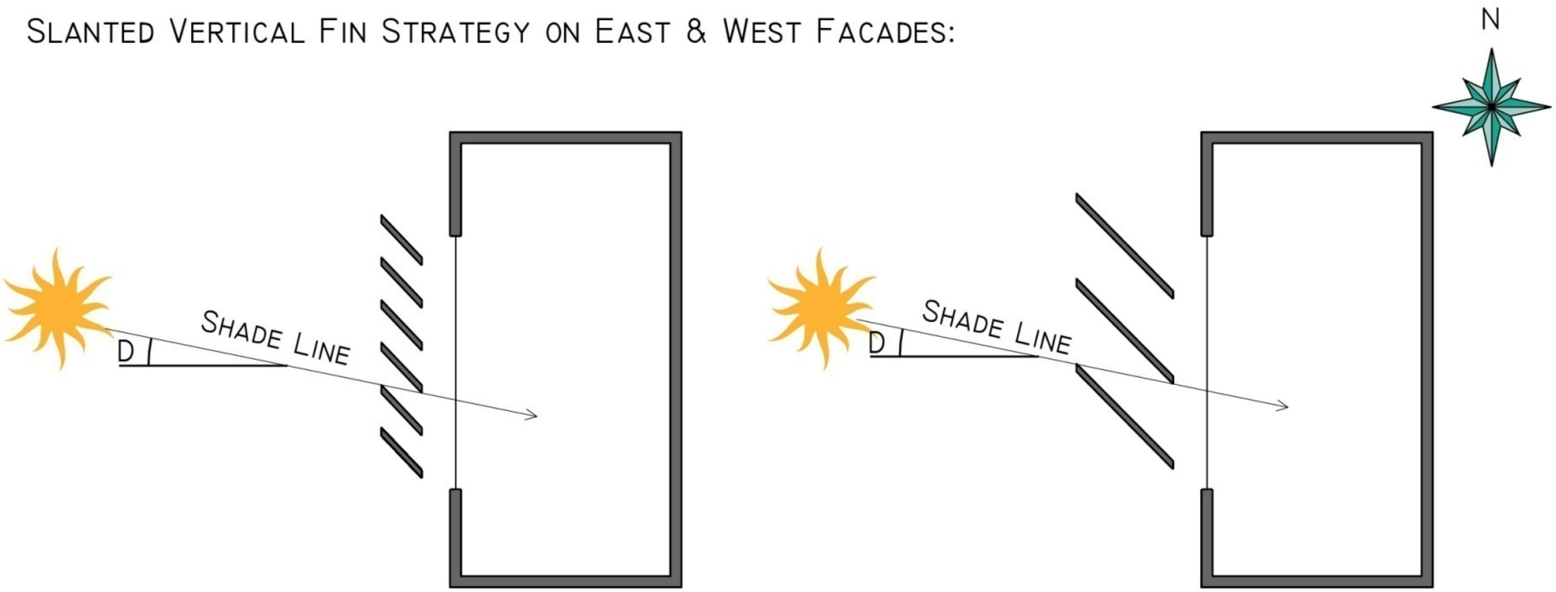
3. Use Vertical Fins. Spacing is an issue, as well as fin length. Must be understood that if to be effective, they will severely restrict the view.

TABLE 9.12
SHADE LINE ANGLE FOR SLANTED VERTICAL FINS*

Latitude	Angle "D"
24	18
28	15
32	12
36	10
40	9
44	8
48	7

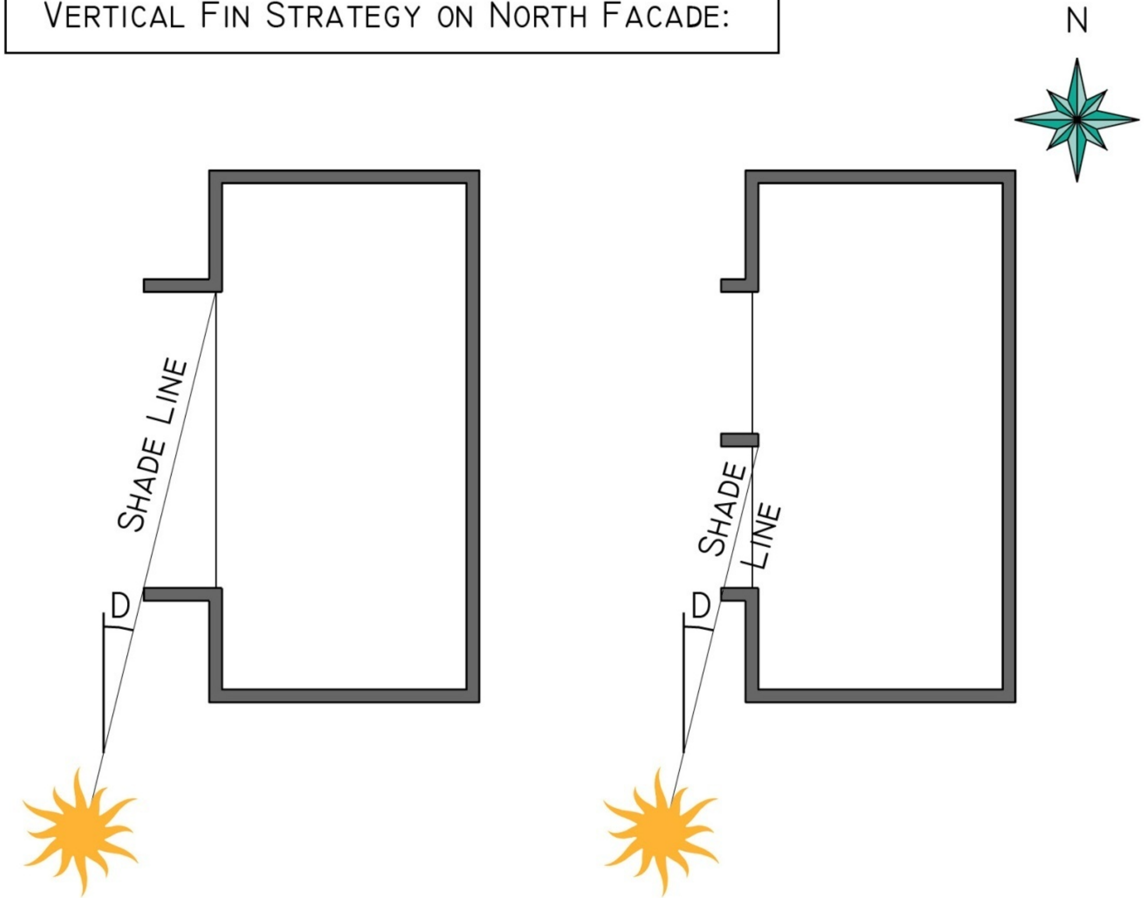
*This table is for vertical fins slanted toward the north on east or west windows. Designs based on this table will provide shade from direct sun for the whole year between the hours of 7 A.M. and 5 P.M. (solar time). This table can also be used to design vertical fins on north windows for the same time period.

Slanted Vertical Fin Strategy on East & West Facades:



The "Shade Line" at angle "D" determines fin spacing, Depth & Slant

VERTICAL FIN STRATEGY ON NORTH FACADE:



THE "SHADE LINE" AT ANGLE "D" DETERMINES FIN SPACING & DEPTH.

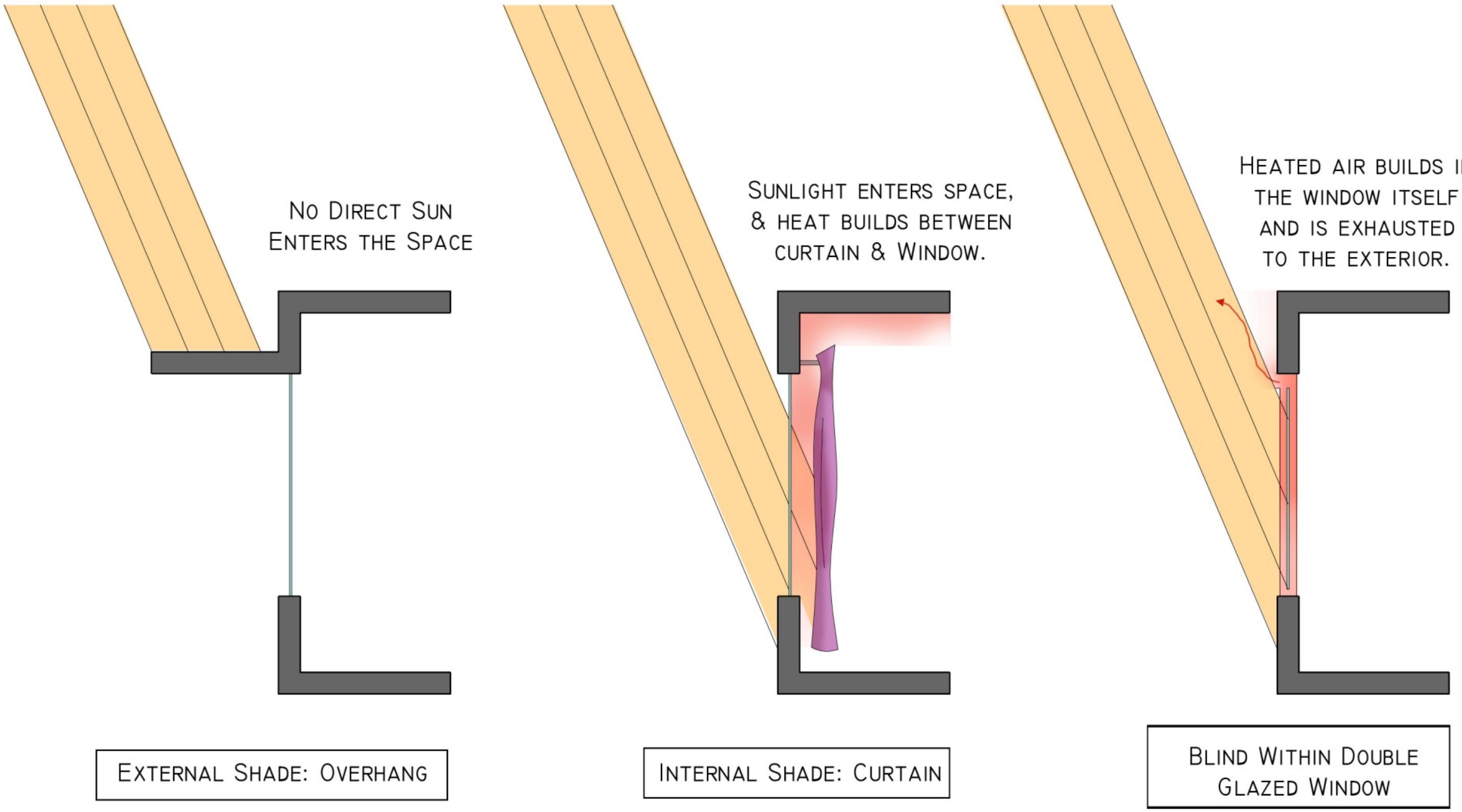
TABLE 9.12
SHADE LINE ANGLE FOR SLANTED VERTICAL FINS *

Latitude	Angle "D"
24	18
28	15
32	12
36	10
40	9
44	8
48	7

* This table is for vertical fins slanted toward the north on east or west windows. Designs based on this table will provide shade from direct sun for the whole year between the hours of 7 A.M. and 5 P.M. (solar time). This table can also be used to design vertical fins on north windows for the same time period.

The sun also hits the façade from the north east and north west during the summer. Fins can be used to control this oblique light as well. It is a function of the latitude, window size and fin depth/frequency.

Interior vs. Exterior Shades



Once the heat is IN, it is IN!

Interior Shading Devices

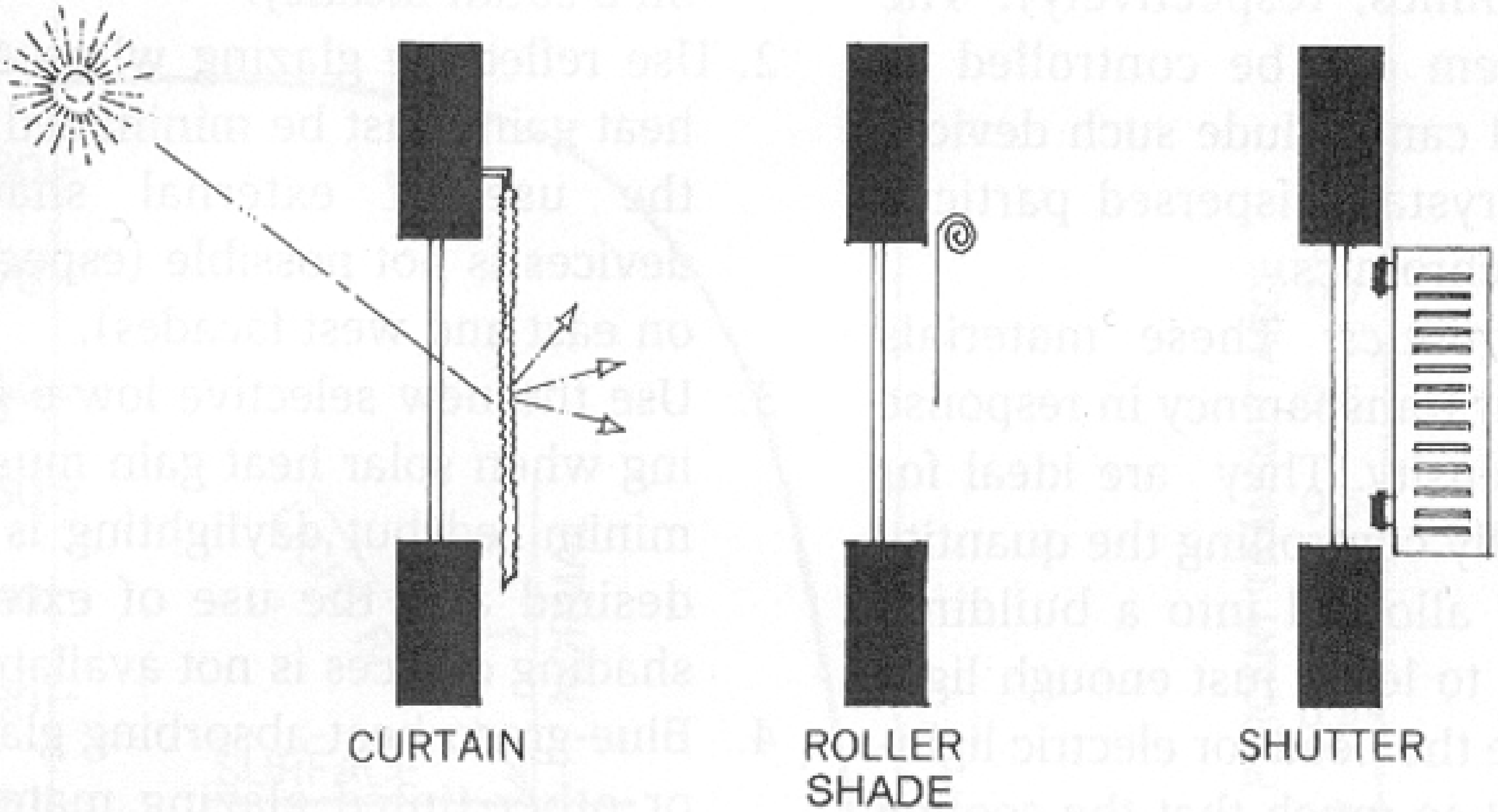


Figure 9.19a Interior shading devices for solar control.

These do NOT control heat gain -- only issues of glare.

HCL

Interior Shading Devices

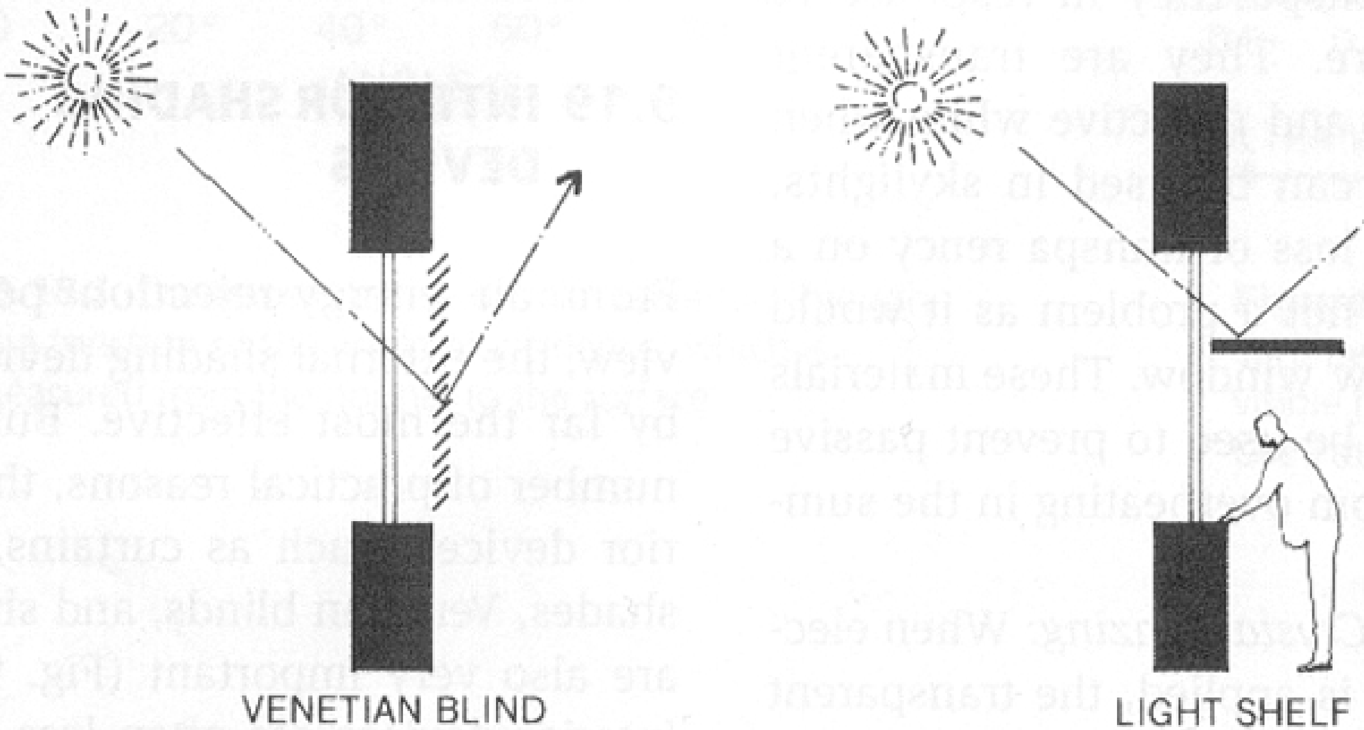


Figure 9.19b Interior shading devices that contribute to quality daylighting.

Interior blinds CAN be used to assist in daylighting and light distribution within the space. *They do not control heat from solar gain.*

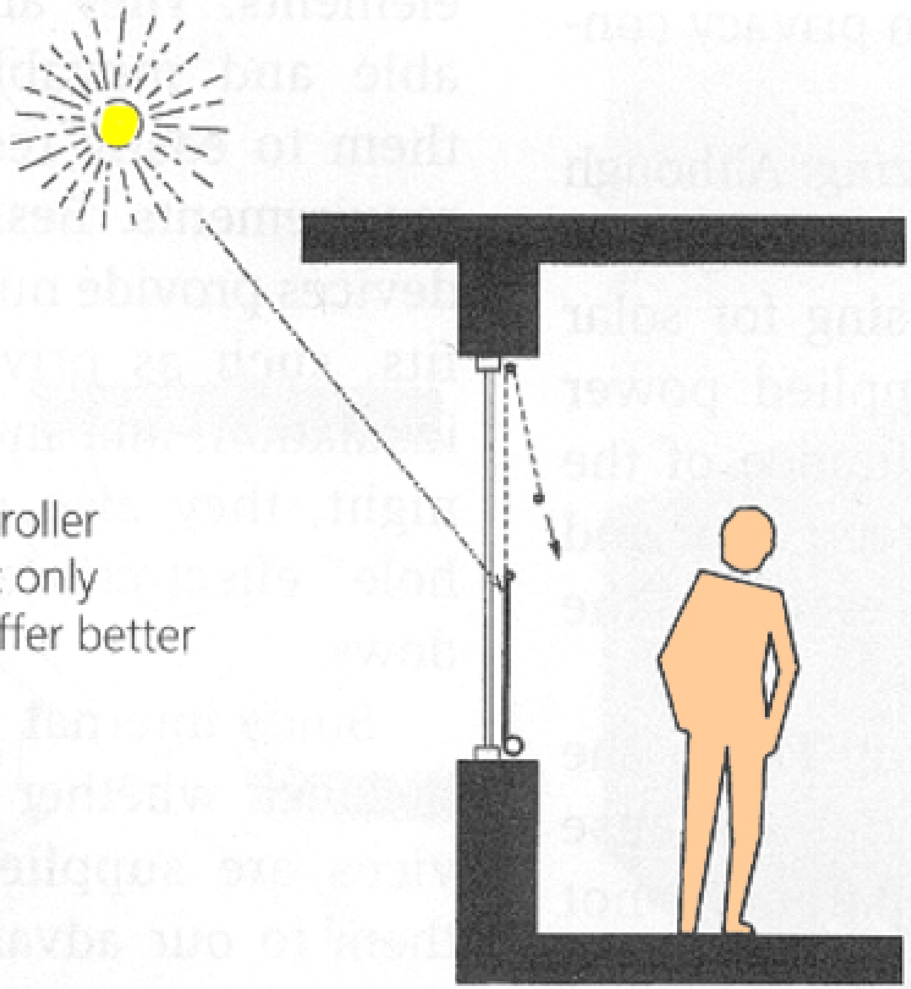
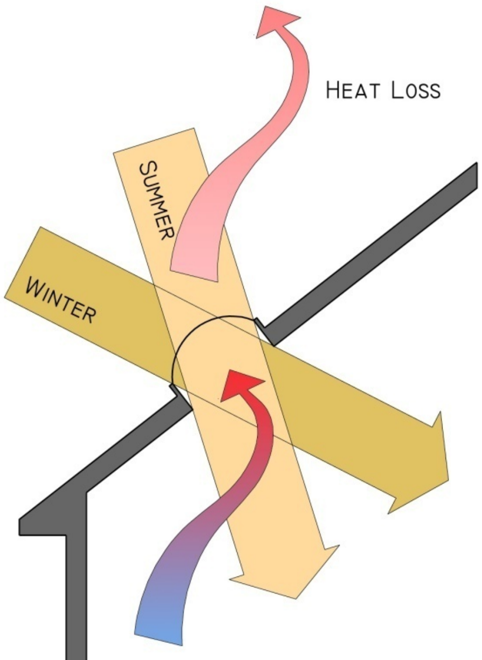


Figure 9.19c When roller shades roll up, they not only shade better but also offer better privacy.

HCL

Skylights vs. Clerestories

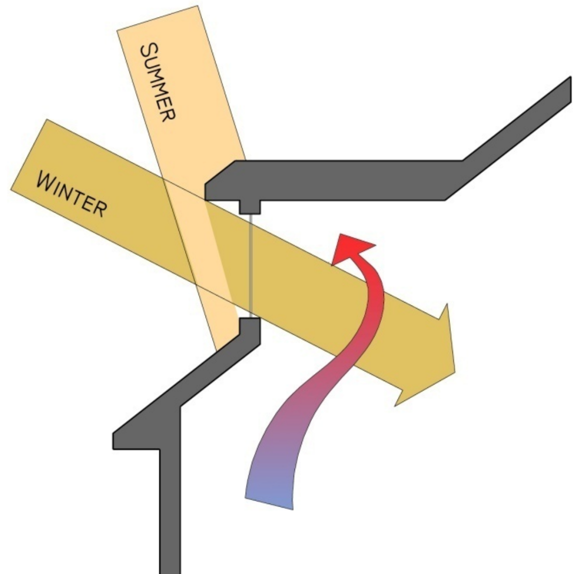
SLOPED/HORIZONTAL GLAZING: SKYLIGHT



SKYLIGHTS DO NOT DISCRIMINATE BETWEEN SUMMER & WINTER SOLAR ADMITTANCE, WHILE ALSO CREATING A HOLE IN THE INSULATED ROOF STRUCTURE.

● RESULT = OVERHEATING IN SUMMER & EXCESSIVE HEAT LOSS IN WINTER

VERTICAL GLAZING: DORMER/CLERESTORY



VERTICAL GLAZING ALLOWS SOLAR ADMITTANCE IN WINTER & NOT IN SUMMER, WHILE ALSO MAINTAING A COMPLETE INSULATED ROOF STRUCTURE.

● RESULT = NATURAL DAYLIGHTING & THERMAL COMFORT YEAR-ROUND

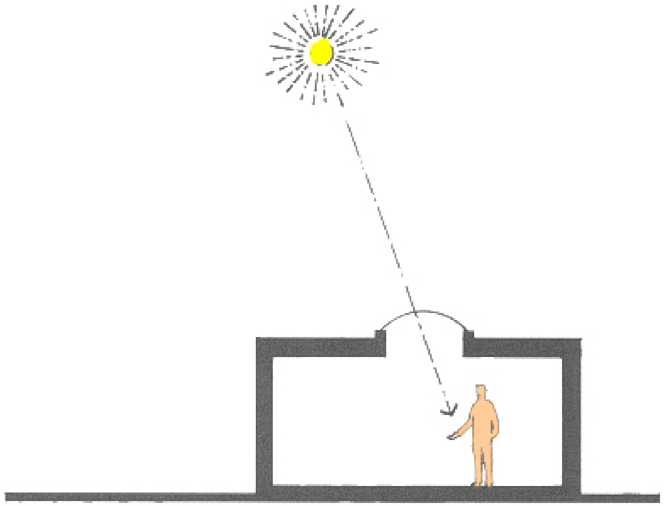


Figure 9.3e Skylights (horizontal glazing) should usually be avoided because they face the summer sun.

HCL

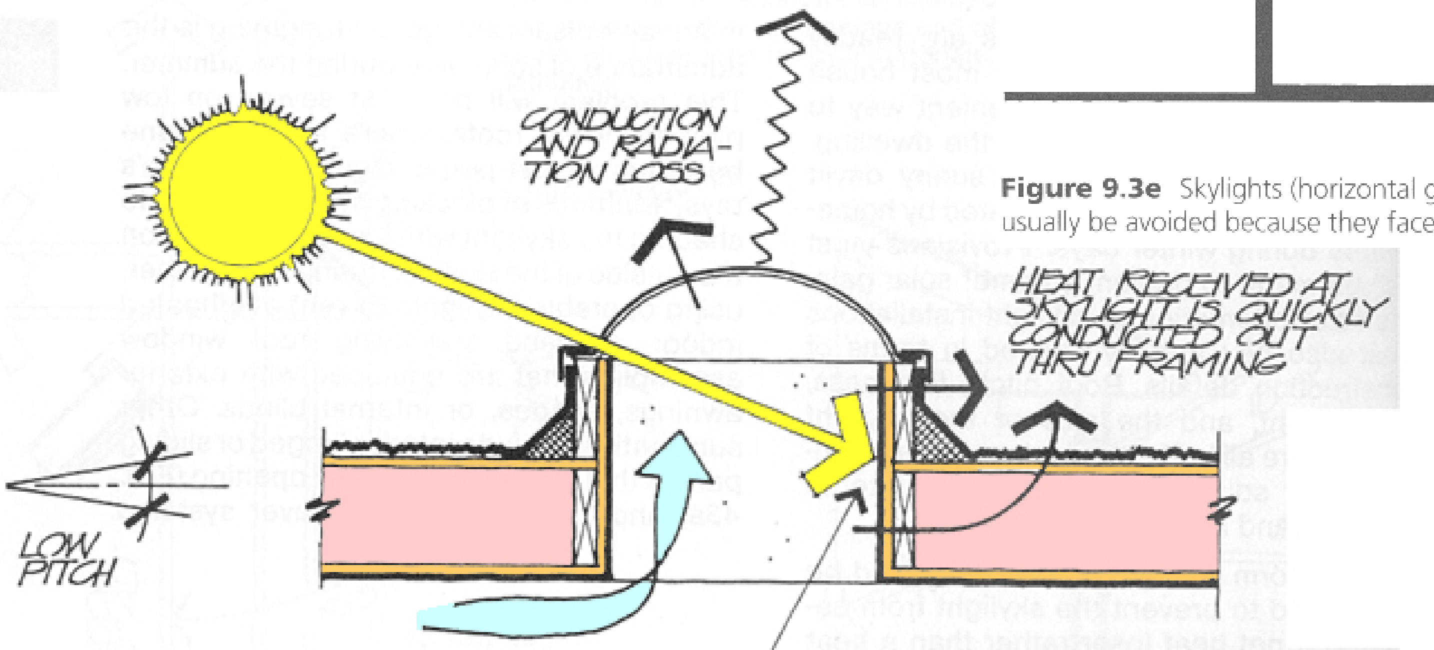


FIG. 43b. **Uninformed use of skylight may result in opening a hole to outward heat loss with little compensating gain. The result may be summer overheating and winter net heat loss.**

CBD

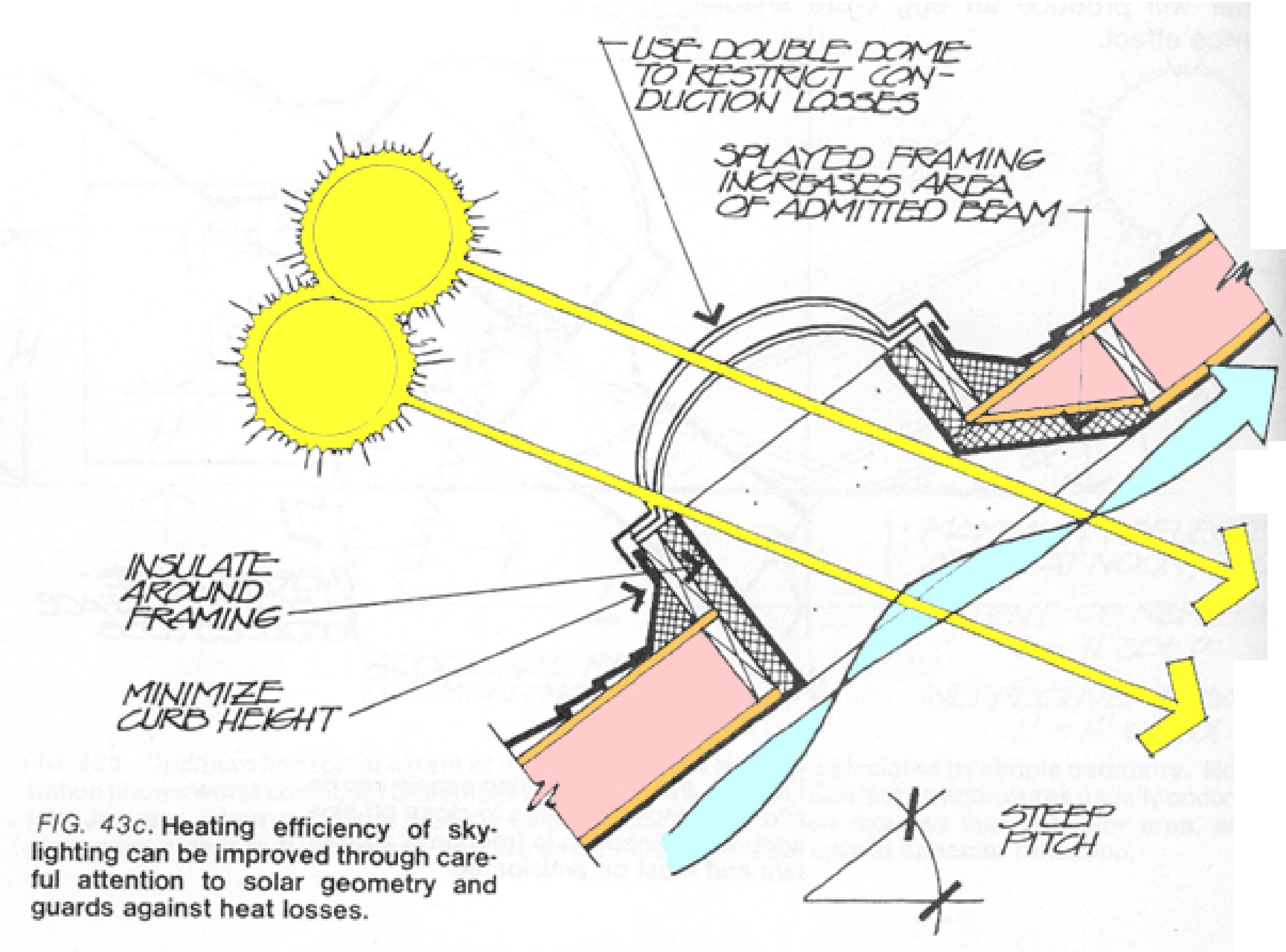
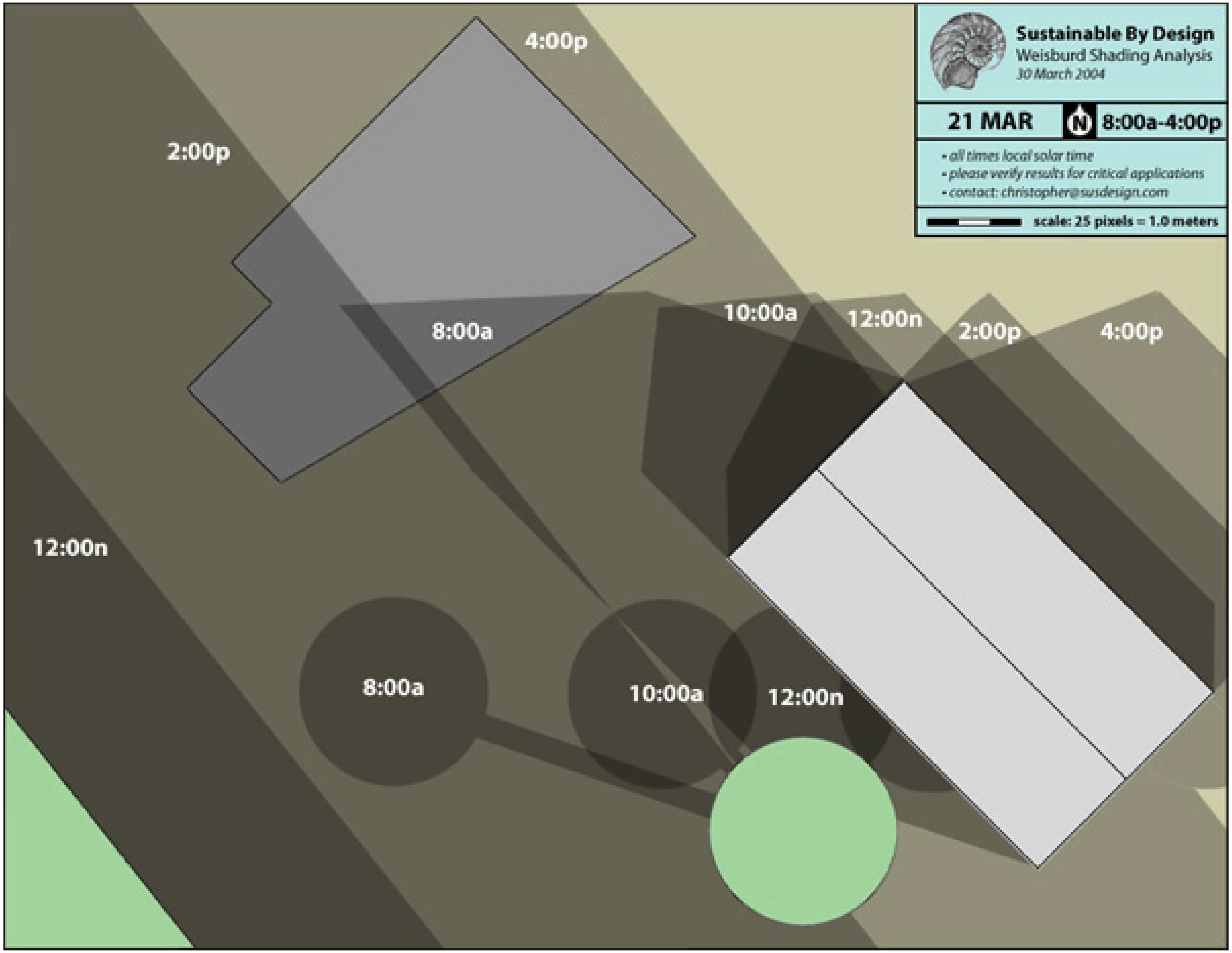


FIG. 43c. **Heating efficiency of skylighting can be improved through careful attention to solar geometry and guards against heat losses.**

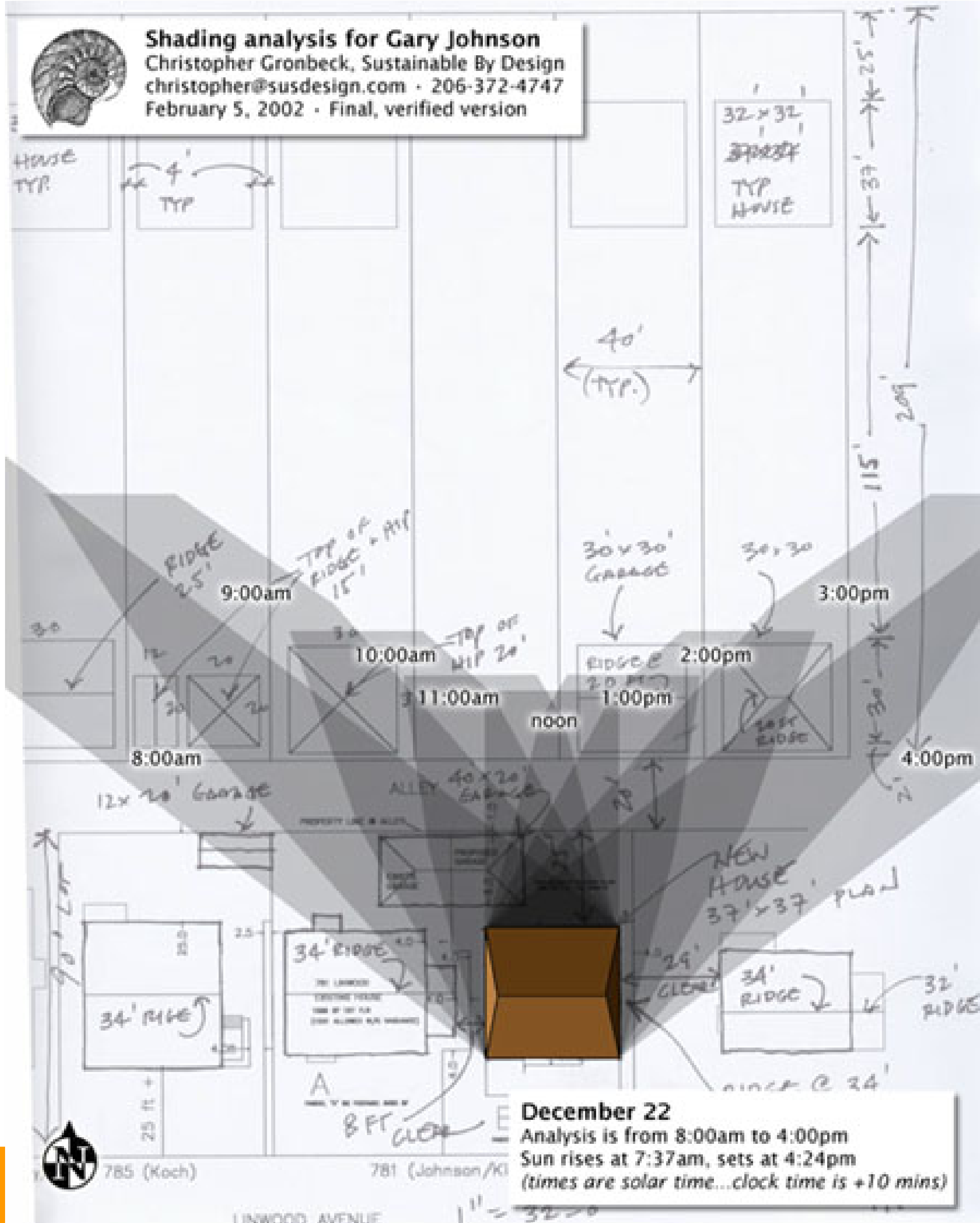
CBD

Learning how to plot shadows...

- important to get a quick and dirty understanding of your building and its shadow patterns (both INTERIOR and EXTERIOR)
- need to do this BEFORE you commit to extensive designs
- can use computers to simulate
- can do sun angle diagrams
- can build a quick massing model and model it on a HELIODON



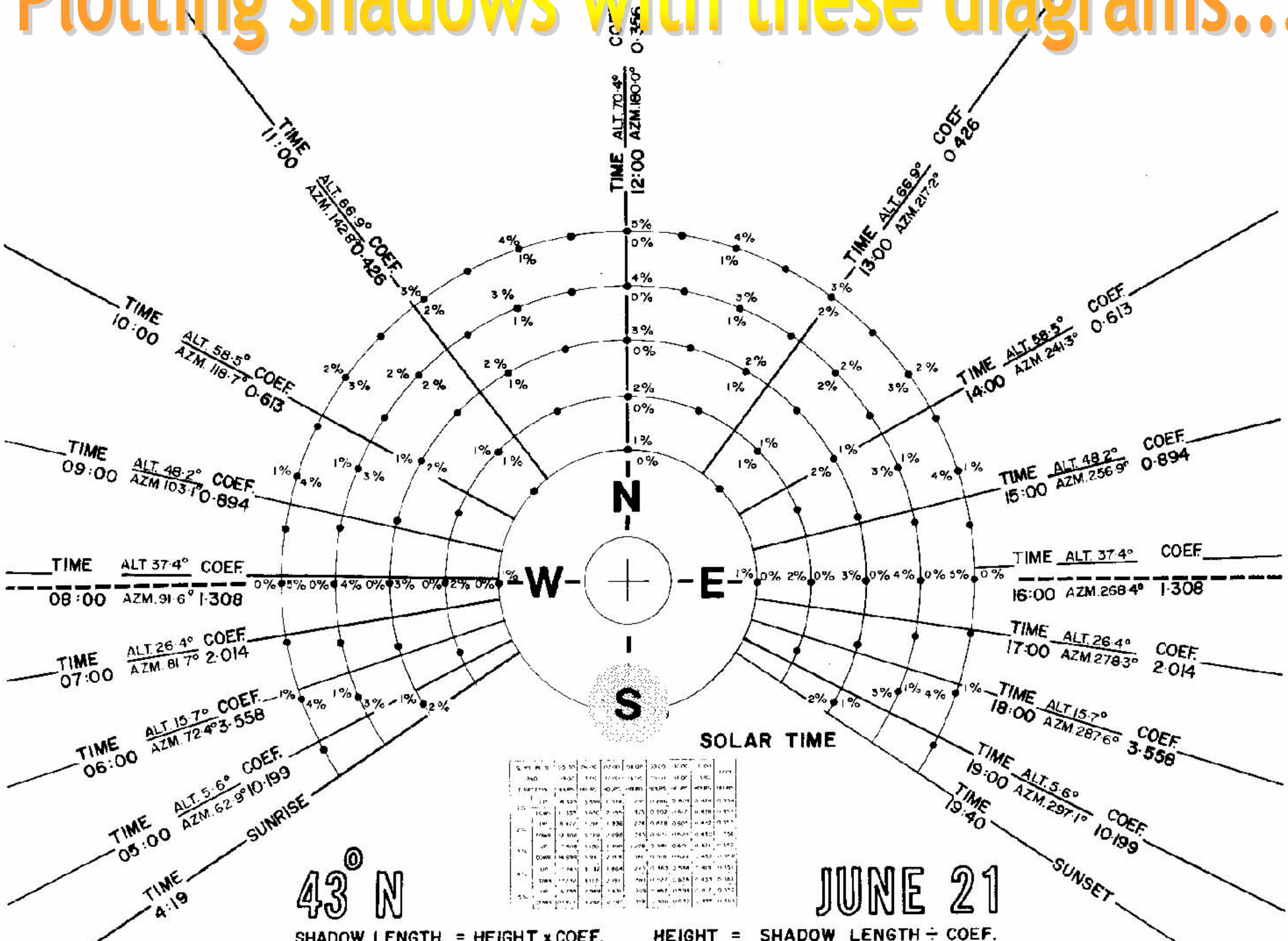
Plotting shadows allows you to understand your site and the effects of the sun on your site at different times of the day and year.



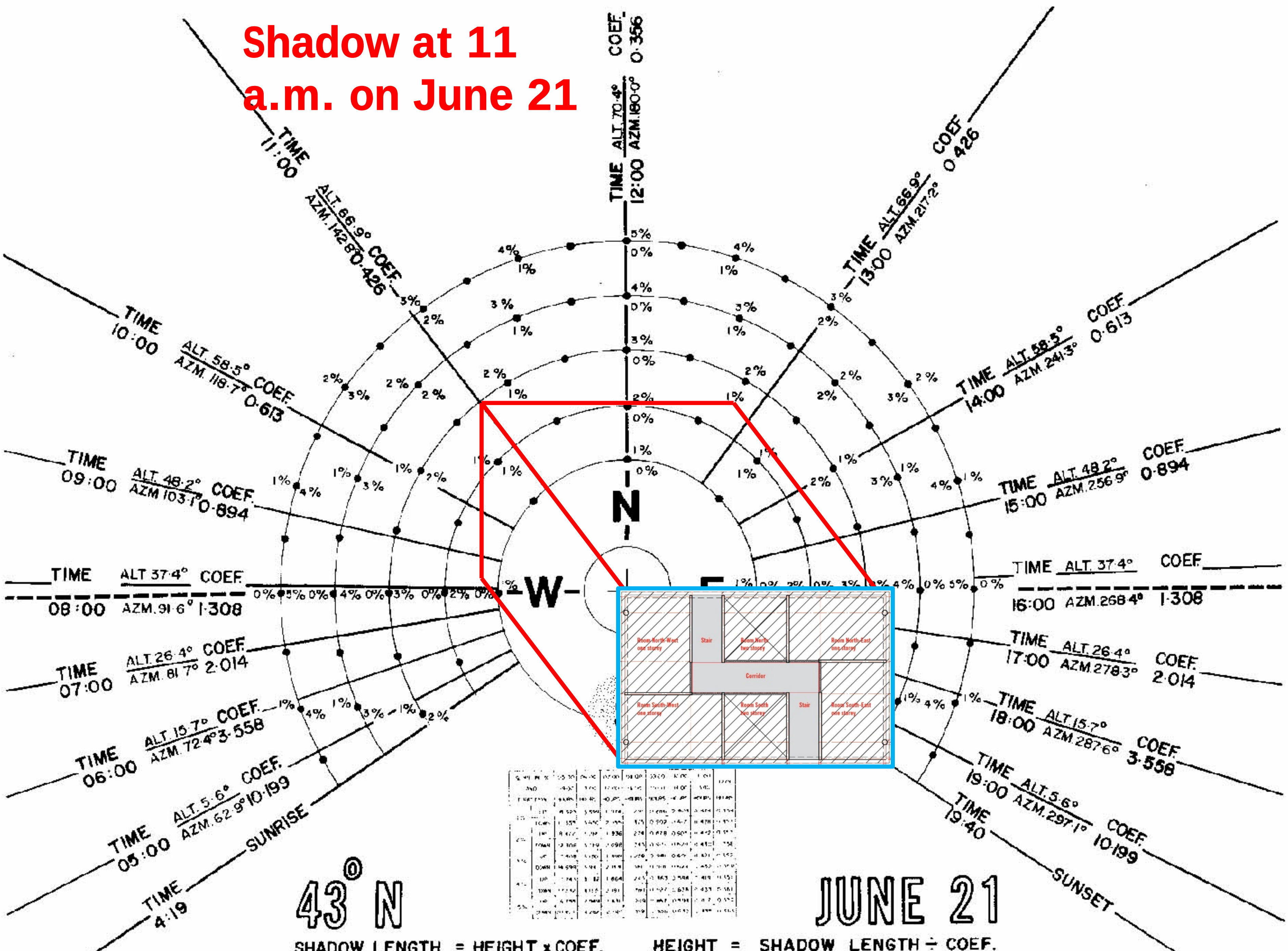
This type of analysis is a "must do" for every building that you design.

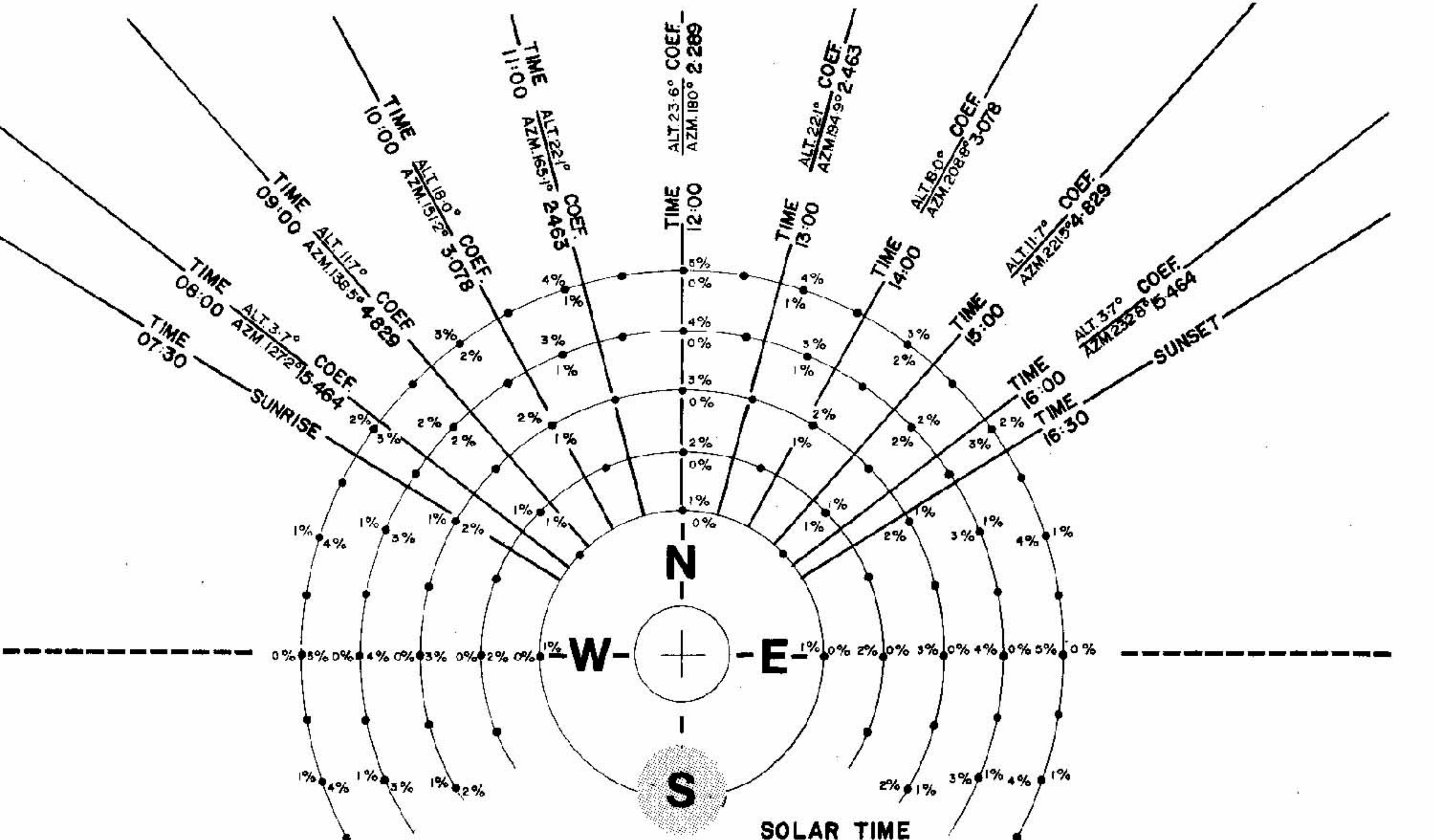
What is MISSING here, is the shading diagrams from the neighbouring properties (all sides). Their shadows will impact your building too.

Plotting shadows with these diagrams…



Shadow at 11 a.m. on June 21



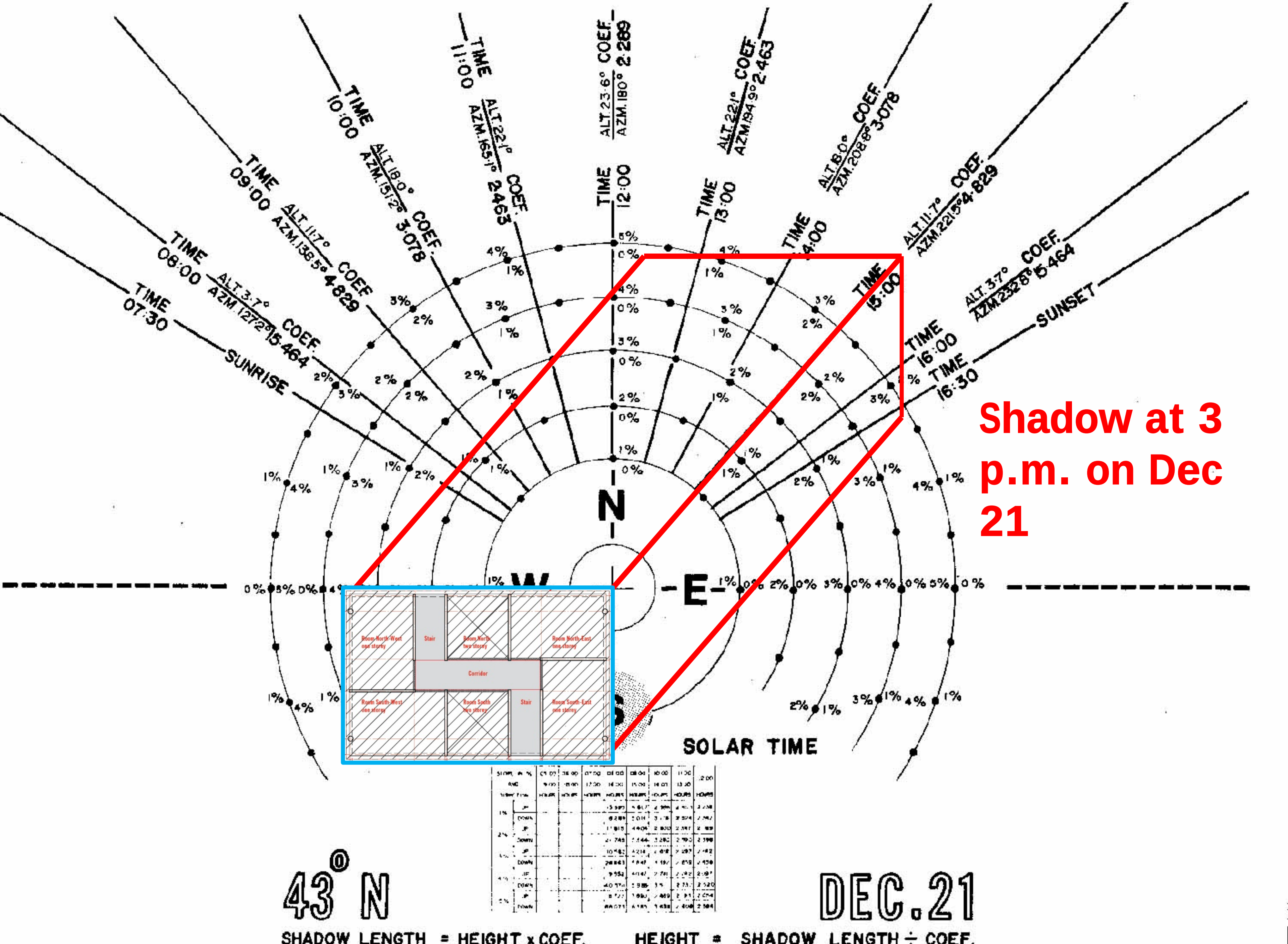


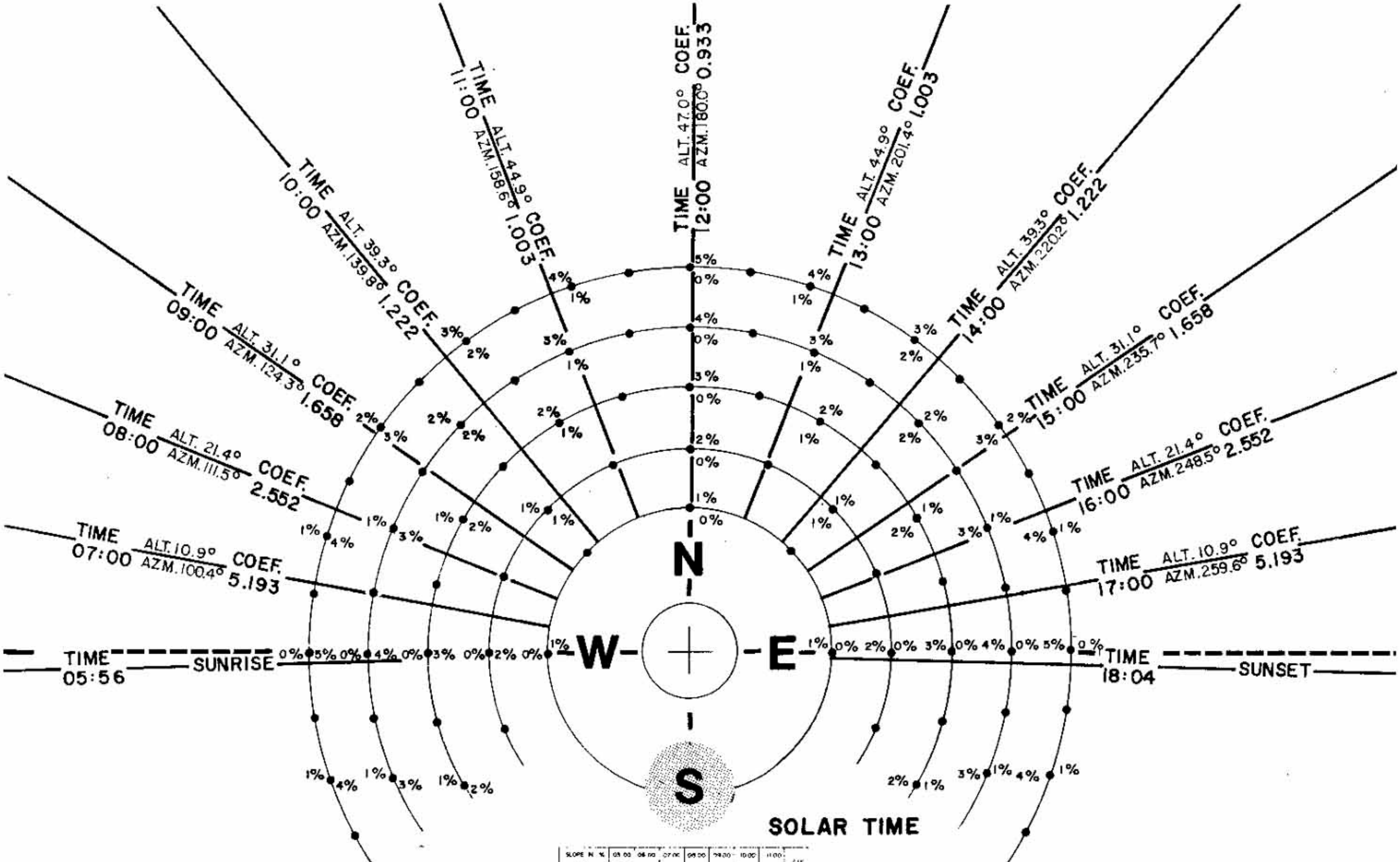
SLOPE IN % AND SLOPE FACE		[illegible] HOURS	[illegible] HOURS	[illegible] HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP				15.5[illegible]	5.607	2.9[illegible]	2.5[illegible]	2.258
	DOWN				8.289	[illegible]	3.178	2.574	[illegible]
2%	UP				11.815	4.404	2.800	2.387	[illegible]
	DOWN				21.749	5.444	3.280	2.790	2.390
3%	UP				10.582	4.214	2.618	2.297	2.[illegible]2
	DOWN				26.843	6.047	4.197	2.659	2.430
4%	UP				9.554	4.047	2.741	2.282	2.[illegible]
	DOWN				40.[illegible]	5.985	3.5	2.7[illegible]	2.520
5%	UP				8.727	3.890	2.489	2.[illegible]	2.054
	DOWN				88.071	6.185	3.658	2.406	2.504

43° N

DEC. 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.


Shadow at 3 p.m. on Dec 21
SOLAR TIME
43° N
DEC.21
SHADOW LENGTH = HEIGHT x COEF.
HEIGHT = SHADOW LENGTH ÷ COEF.
SUNRISE
SUNSET
TIME 07:30
TIME 08:00
ALT.3.7° AZM.127.2° COEF. 15.464
TIME 09:00
ALT.11.7° AZM.138.5° COEF. 4.829
TIME 10:00
ALT.18.0° AZM.151.2° COEF. 3.078
TIME 11:00
ALT.22.1° AZM.165.1° COEF. 2.463
TIME 12:00
ALT.23.6° AZM.180° COEF. 2.289
TIME 13:00
ALT.22.1° AZM.194.9° COEF. 2.463
TIME 14:00
ALT.18.0° AZM.208.8° COEF. 3.078
TIME 15:00
ALT.11.7° AZM.221.5° COEF. 4.829
TIME 16:00
ALT.3.7° AZM.232.8° COEF. 15.464
TIME 16:30
N
W
E
S
Room North-West one storey
Stair
Room North two storey
Room North-East one storey
Corridor
Room South-West one storey
Room South two storey
Stair
Room South-East one storey

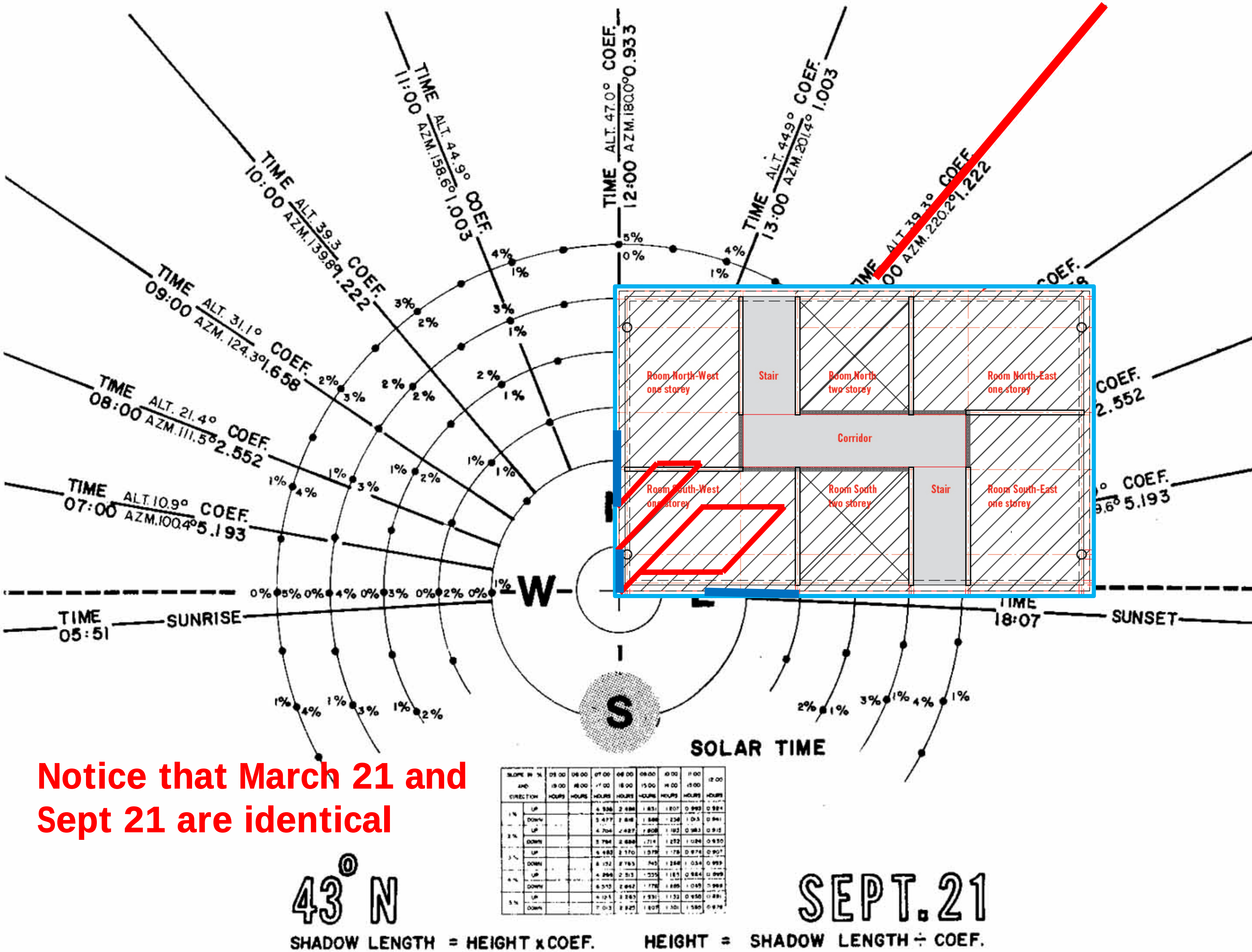


SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP			4.936	2.488	1.610	1.207	0.905	0.924
	DOWN			5.477	2.618	1.666	1.227	1.013	0.941
2%	UP			4.704	2.428	1.605	1.193	0.983	0.915
	DOWN			5.794	2.669	1.714	1.252	1.024	0.900
3%	UP			4.493	2.370	1.579	1.179	0.974	0.907
	DOWN			6.151	2.765	1.744	1.268	1.036	0.959
4%	UP			4.296	2.315	1.554	1.164	0.965	0.899
	DOWN			6.333	2.847	1.776	1.285	1.045	0.969
5%	UP			4.121	2.221	1.530	1.152	0.955	0.891
	DOWN			7.203	2.925	1.807	[illegible]	1.056	0.979

43° N   MARCH 21

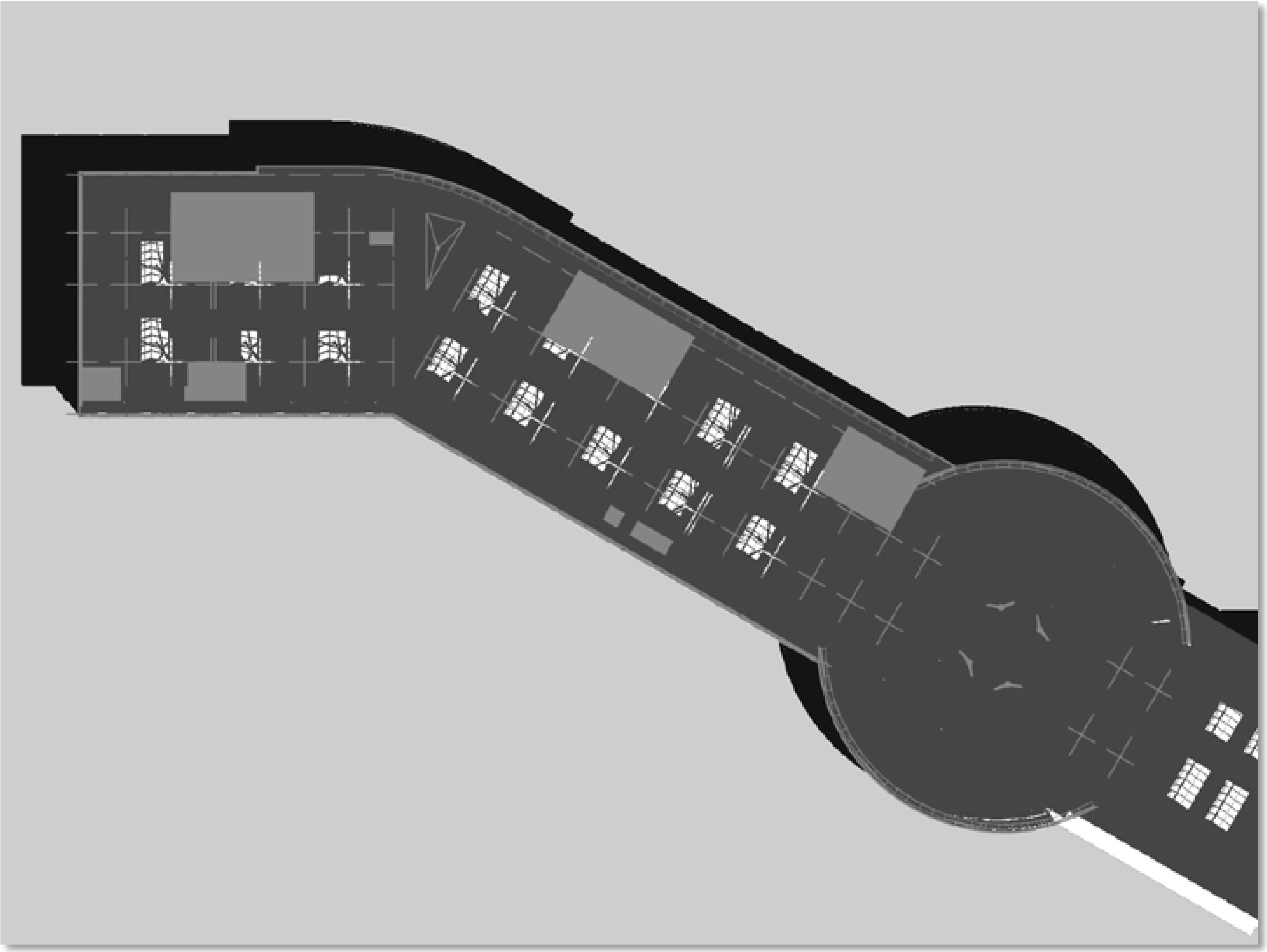
SHADOW LENGTH = HEIGHT x COEF.   HEIGHT = SHADOW LENGTH ÷ COEF.



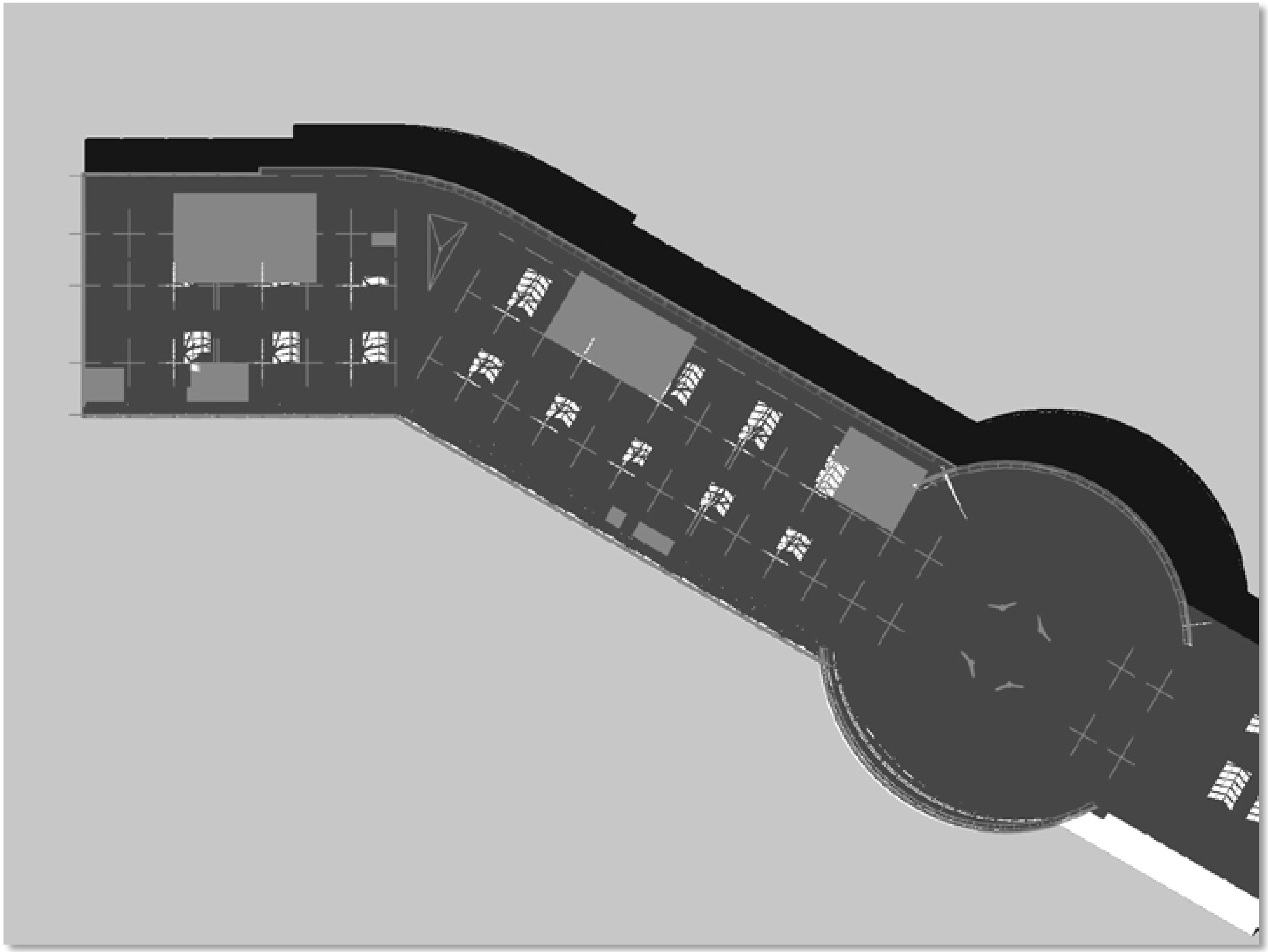
Notice that March 21 and Sept 21 are identical

Modelling with a Heliodon...

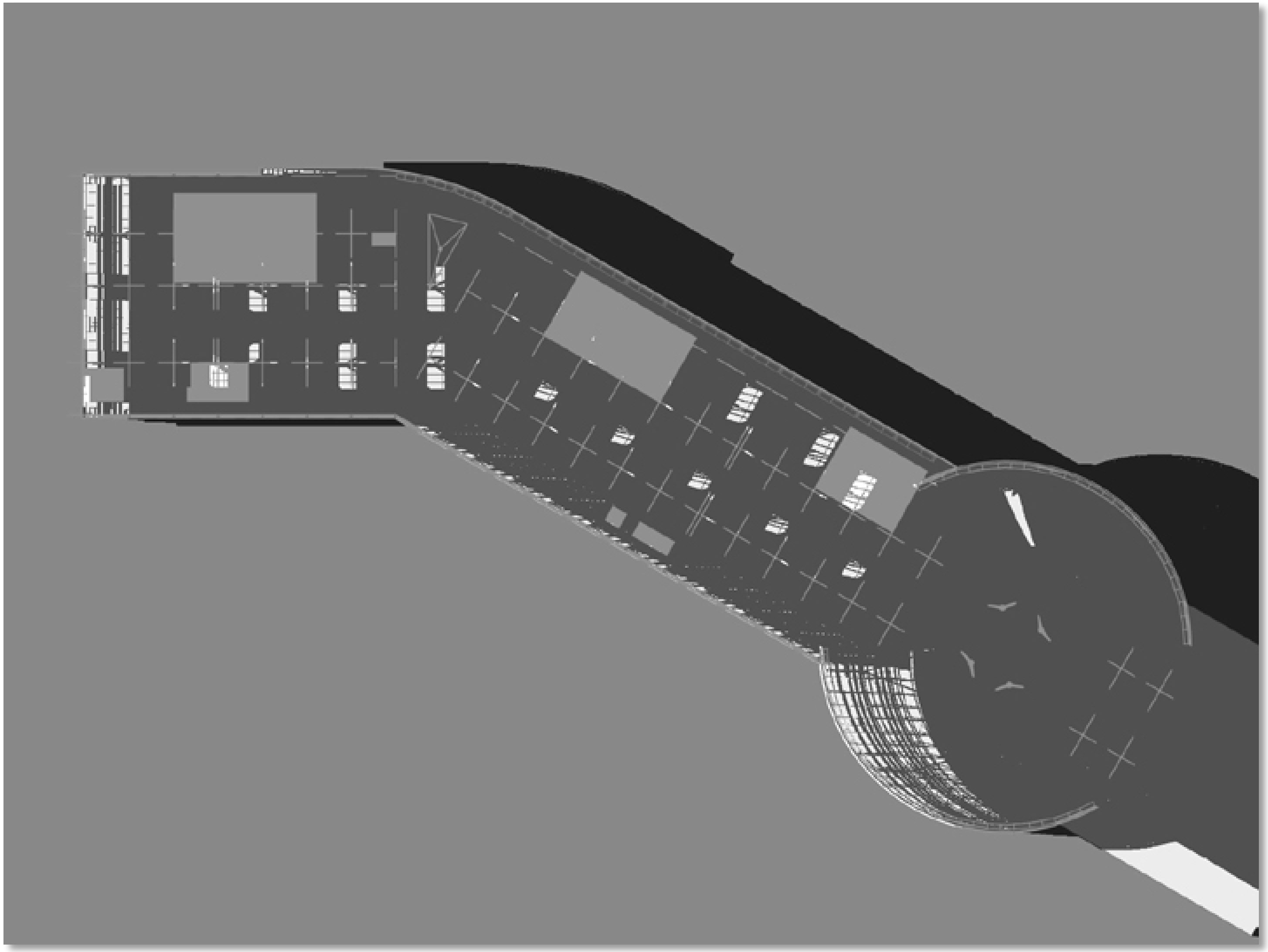
Vancouver Airport Authority: summer solstice noon



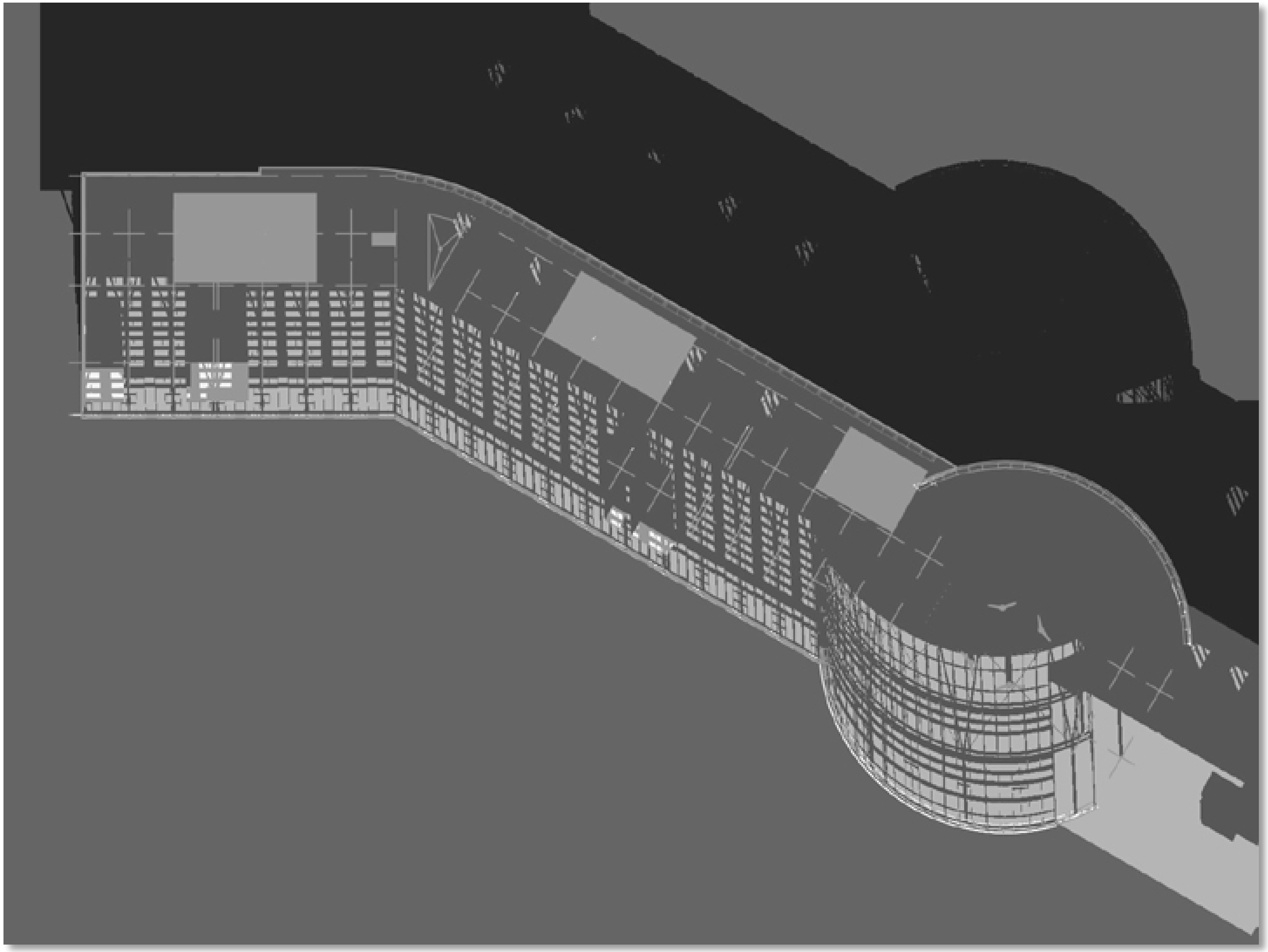
YVR: summer solstice 3pm



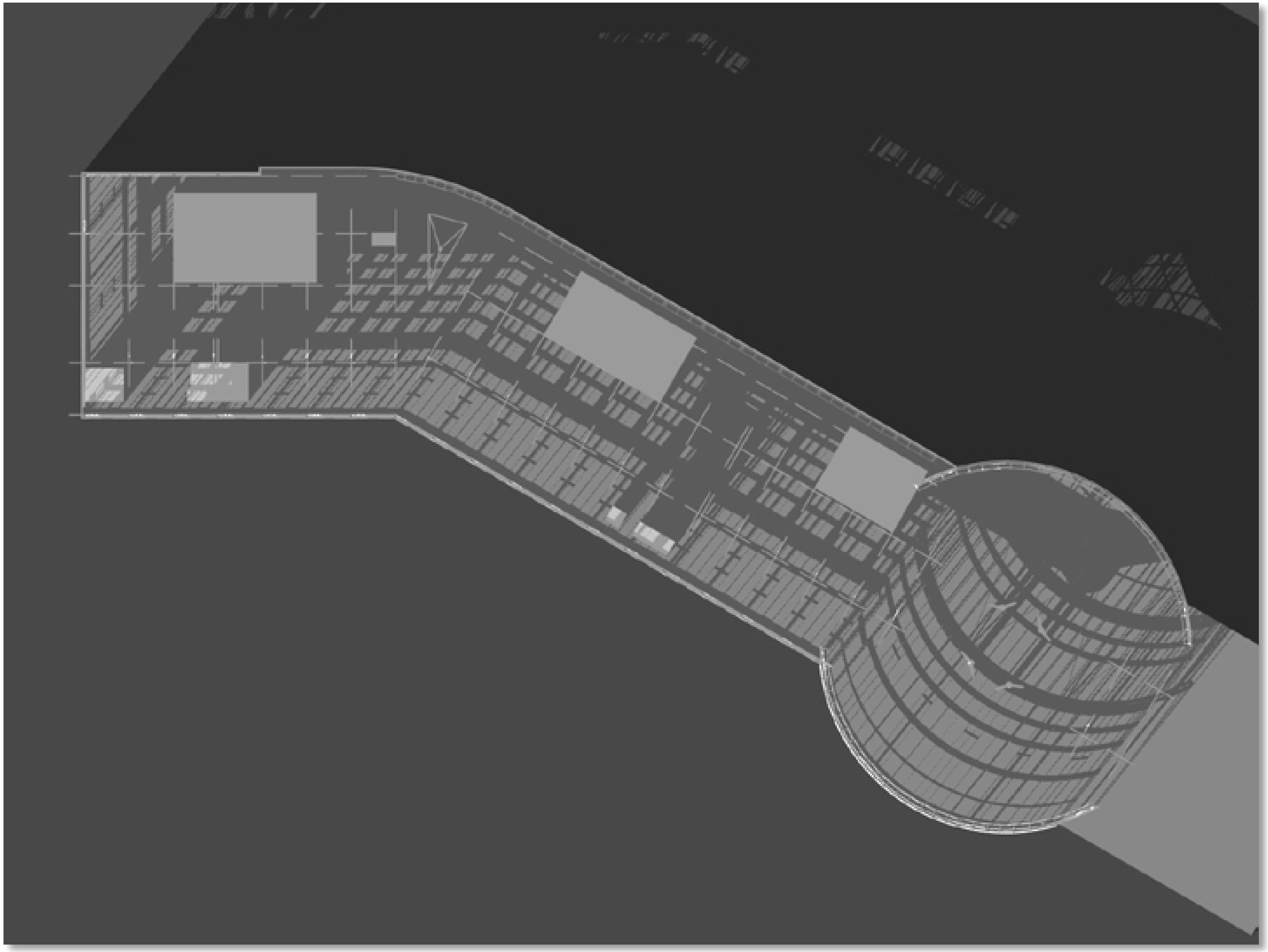
YVR: summer solstice 6 pm



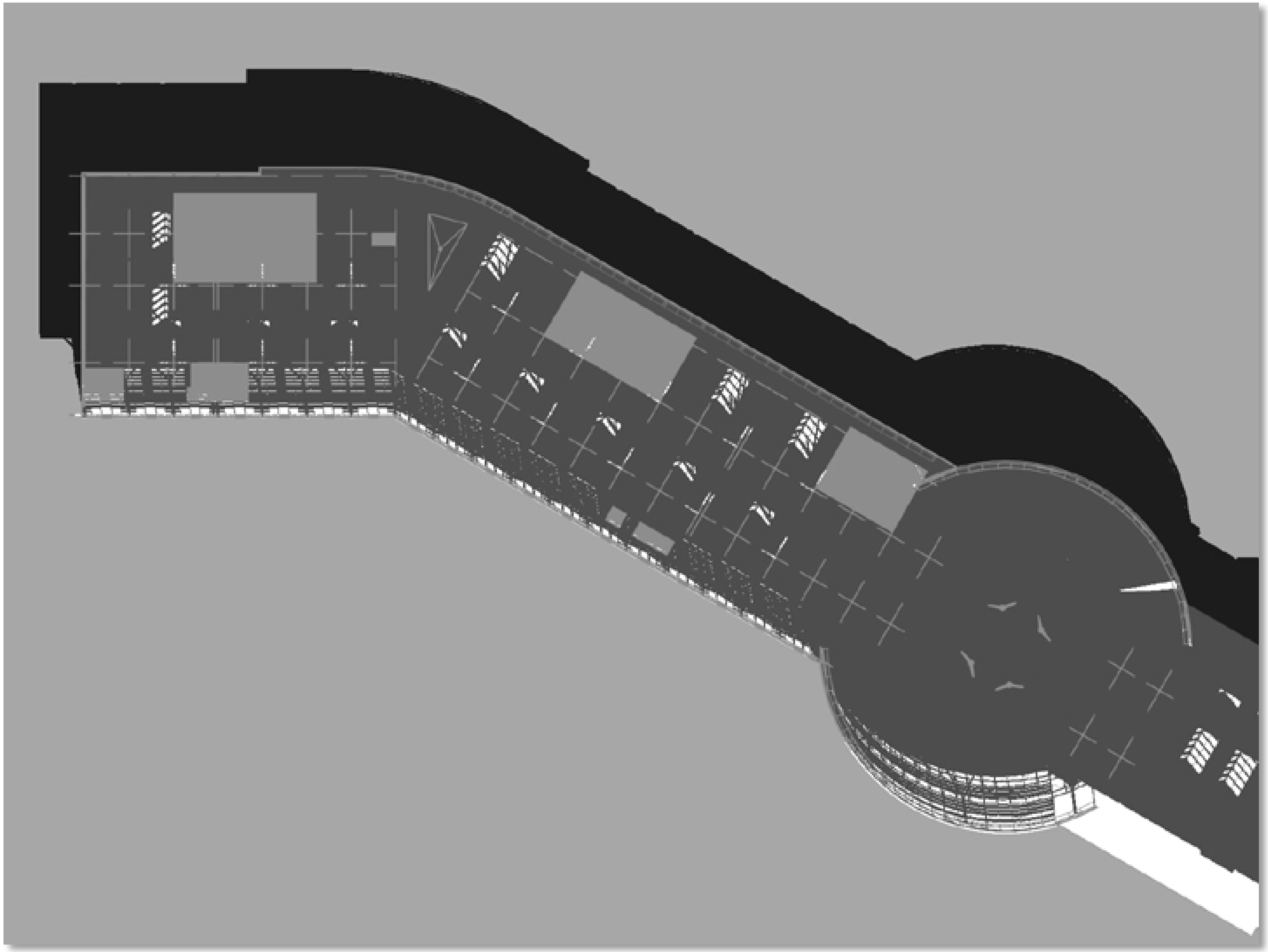
YVR: winter solstice noon



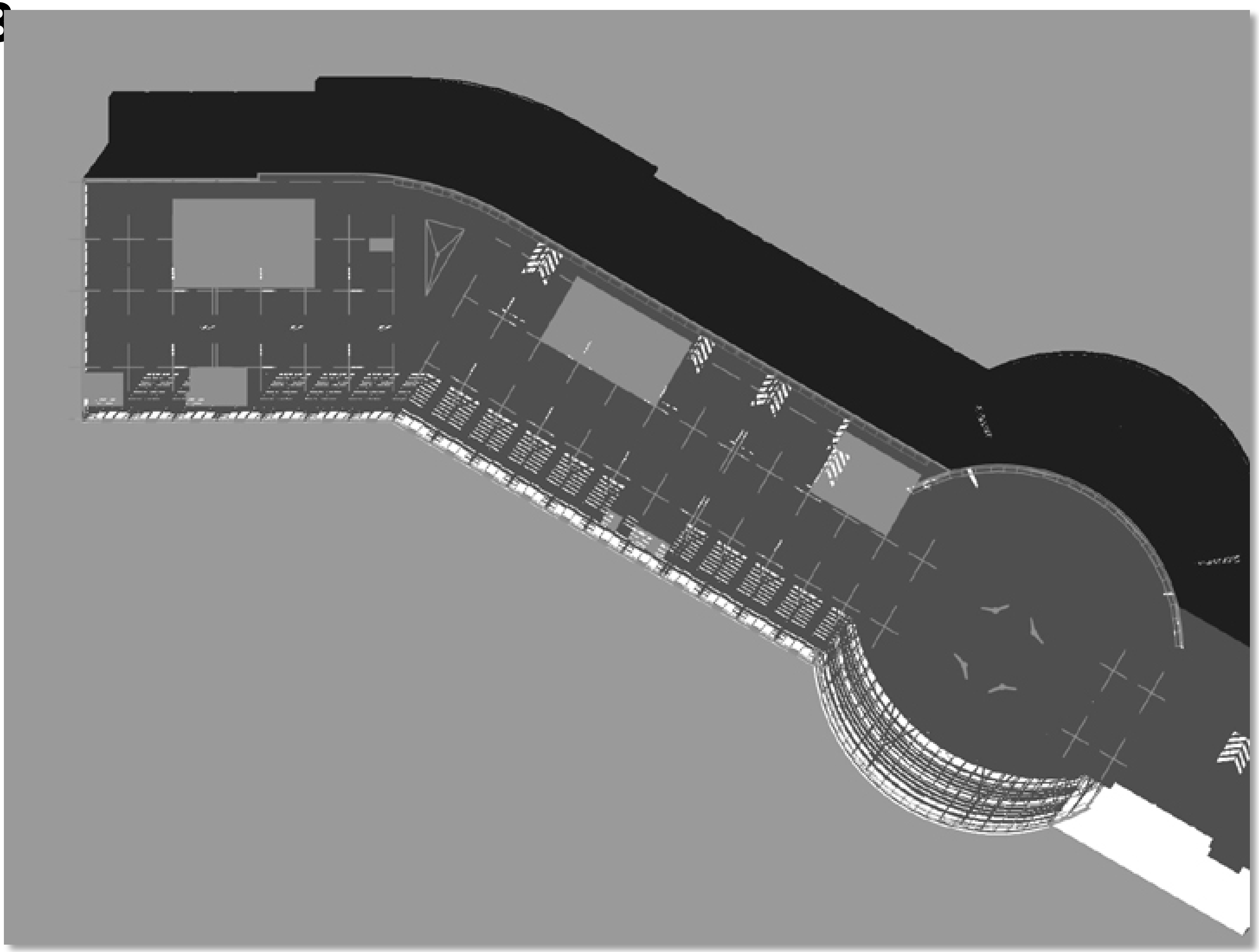
YVR: winter solstice 3 pm



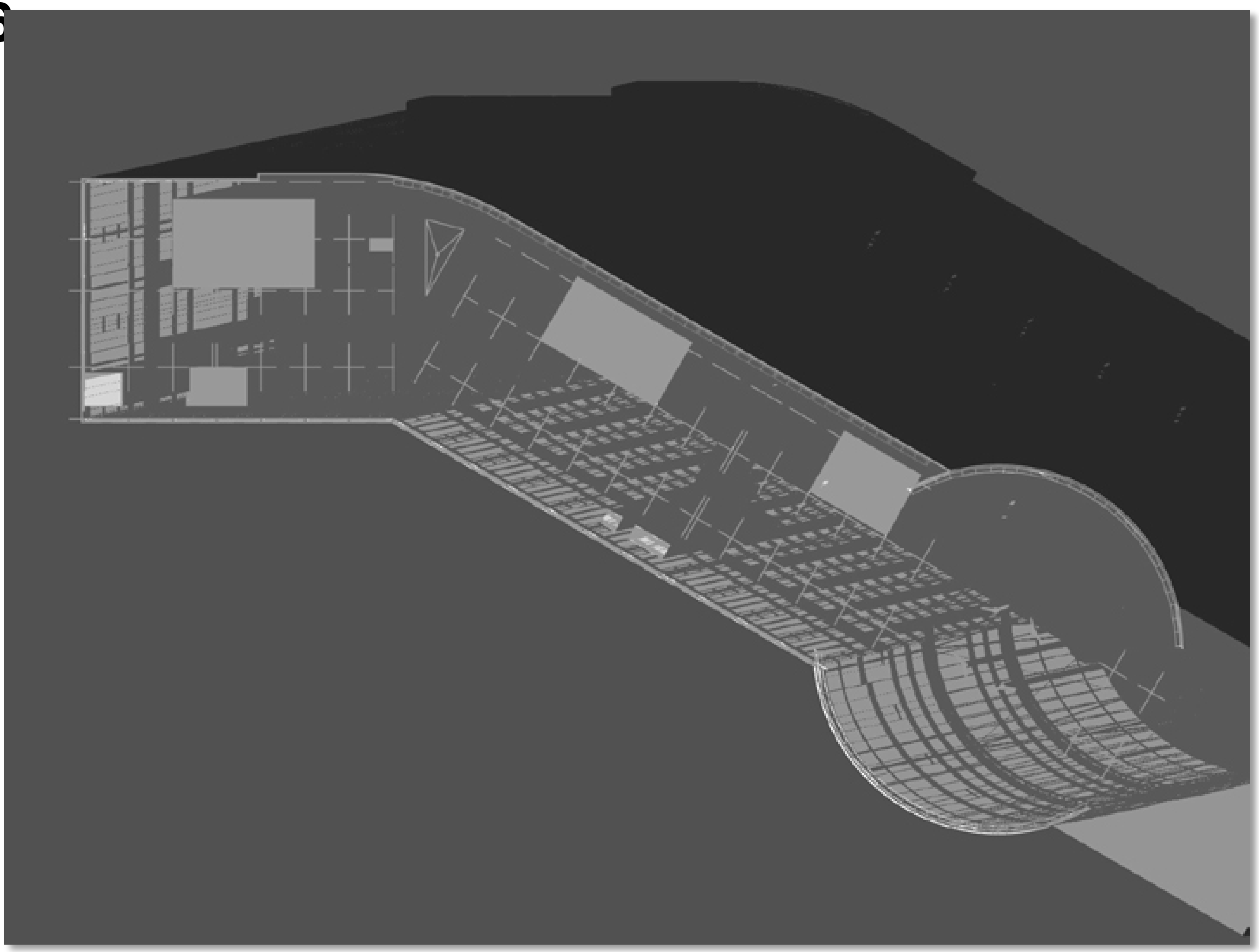
YVR: spring/fall equinox noon

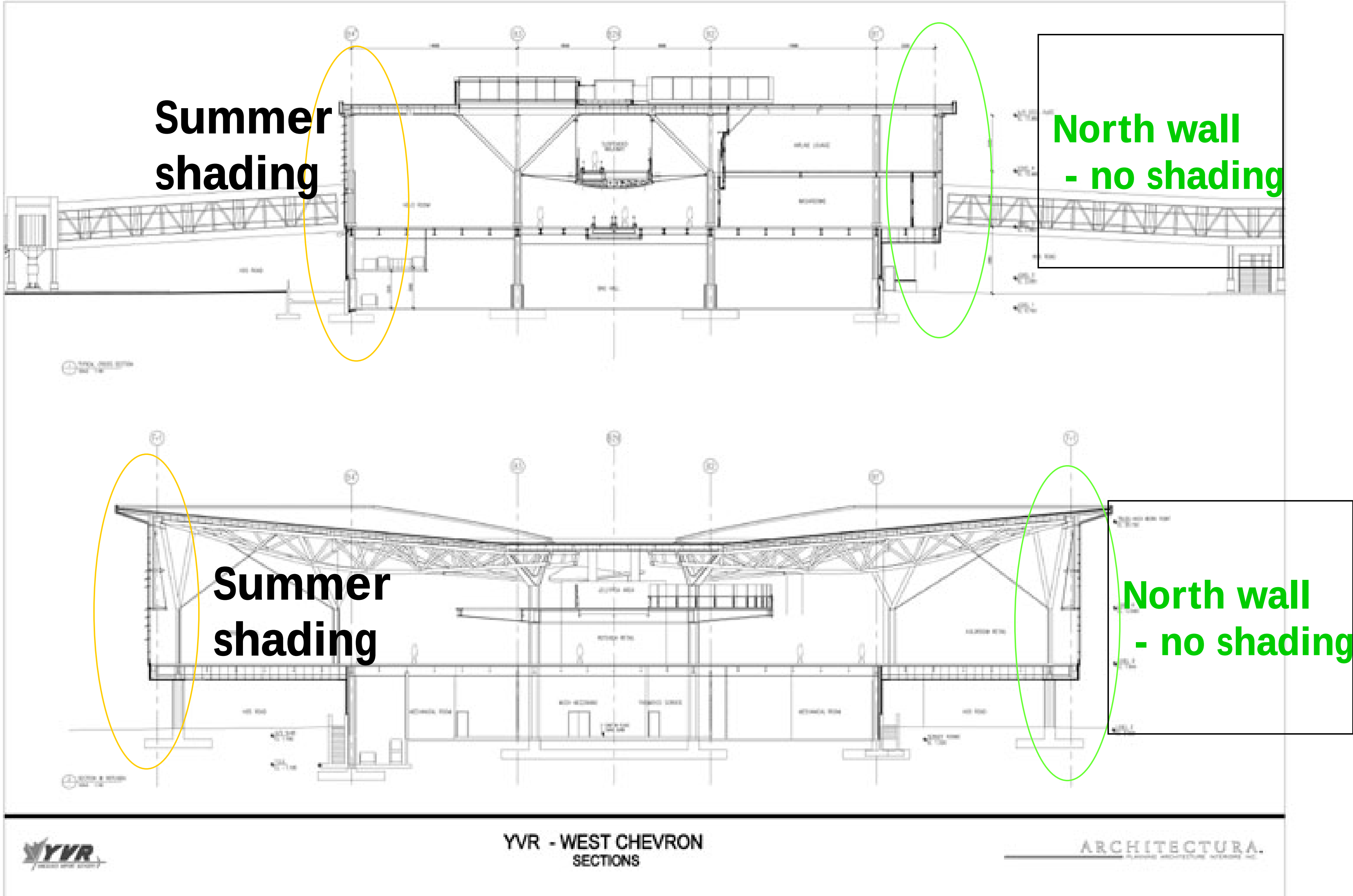


YVR: spring/fall equinox 3



YVR: spring/fall equinox 6




Summer shading
North wall - no shading
Summer shading
North wall - no shading
YVR - WEST CHEVRON
SECTIONS
ARCHITECTURA

Exterior shading devices (horizontal fins) are proposed for the south side of the terminal wall to cut down on solar gain in the highly glazed space during the summer months. Solar gain is still permitted during the winter.